Regional Inequality and Industrial Structure in Japan: 1874-2008

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Tatsuji Makino, Ralph Paprzycki
Tokihiko Settsu, Masanori Takashima
Joji Tokui

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Regional Inequality and Industrial Structure in Japan: 1874–2008 presents a detailed examination of long-term trends in prefectural income inequality and its determinants. The first part of the analysis is based on newly compiled estimates going back to the beginnings of Japan's modern economic development at the start of the Meiji period, while the second part employs detailed prefecture-level data from the R-JIP Database. The analysis shows that changes in industrial structure were a major driver of developments in regional inequality throughout the period, first leading to divergence and then convergence in prefectural per capita incomes. Other key factors shaping trends in regional inequality were domestic migration, government policies, and technology diffusion.

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Preface

This book is the product of a decade of work at the core of which is the construction of a database for the analysis of prefectural economic development during the period 1874–2008. This database makes it possible to examine changes in regional inequality in Japan more or less from the start of Japan's modern economic development in the early Meiji period. In addition to the construction and analysis of this database, the book also presents regional estimates of economic activity during the Tokugawa period and, on the basis of estimates of capital stock and total factor productivity (TFP), a detailed examination of the role of capital accumulation and technology in regional inequality during the post-war period.

A study of this magnitude would not have been possible without the financial support of various funding bodies and the cooperation of numerous scholars. Work on the estimation of gross prefectural products (GPPs) as well prefecture-level labor input and industrial structures for the pre-war period started in 2005 under the CHORUS Program "Regional Inequality and Growth: Investigating the French and Japanese Experiences, 1870–2000" (FY 2005–2007; Project Leaders: Jean-Pierre Dormois, Sciences Po Bordeaux, and Kyoji Fukao) funded by the Japan Society for the Promotion of Science (JSPS) and the French National Research Agency. This work was continued as part of the Hitotsubashi University 21st Century Center of Excellence (COE) Program "Research Unit for Statistical Analysis in Social Sciences" (FY 2002–2006; Project Leader: Osamu Saito) and the Hitotsubashi University Global-COE Program "Research Unit for Statistical and Empirical Analysis in Social Sciences," (FY 2007–2012; Project Leader: Kyoji Fukao), both funded by the JSPS, and with the help of a JSPS Grant-in-Aid for Research Activity Start-Up for the project "Economic Development and Regional Industrial Structure in Pre-War Japan" (FY 2011–2012; Project Leader: Tokihiko Settsu) and financial support from the Reikei Foundation.

Meanwhile, the work on estimating capital and labor input, labor quality, and TFP by prefecture and industry for the post-war period began in 2011 as a joint project between the "East Asian Industrial Productivity Project" (FY 2011–2013; Project Leader: Kyoji Fukao)

and the "Regional-Level Japan Industrial Productivity Database: Database Refinement and Its Analysis" (FY 2013-2014; Project Leader: Joji Tokui) at RIETI on the one hand and the Institute of Economic Research (IER) at Hitotsubashi University on the other.

Finally, the work on analyzing and integrating this research for the present book took place as part of the following research projects: "The Expansion of the Long-Term Economic Statistics (LTES) and International Comparison of Economic Development" (FY 2013-2014; Project Leader: Kyoji Fukao) funded by the Institute of Statistical Research; the Grant-in-Aid for Scientific Research (B) project "Migration, Productivity, and Regional Income Inequality" (FY 2013-2015) (Project Leader: Kyoji Fukao); and the Grant-in-Aid for Scientific Research for Young Scientists (B) "The Re-Estimation of Tertiary Sector Income in the Pre-War Period—A Revision of the 'Long-Term Economic Statistics'" (FY 2013-2015, Project Leader: Tokihiko Settsu), both funded by the JSPS. We would like to take this opportunity to express our appreciation for the financial support received.

The construction of the database and the analysis based on the database also greatly benefited from the considerable input of a number of scholars. In particular, we would like to thank members involved in the above-mentioned research projects, including Tangjun Yuan (Fudan University), Osamu Saito (Hitotsubashi University), Tsutomu Miyagawa (Gakushuin University), Ximing Yue (Renmin University of China), Tomohiko Inui (Gakushuin University), Nobuyuki Arai (Wakayama University), and Sonoe Arai (RIETI). We are deeply grateful for their collaboration.

When compiling our estimates for the pre-war period, we greatly relied on the Long-Term Economic Statistics (LTES) series compiled here at the IER under the general editorship of Kazushi Ohkawa, Miyohei Shinohara, and Mataji Umemura (and published by Toyo Keizai Shinposha) between 1965 and 1988. What astonished us the most is that even though the aim of the LTES was to construct long-term estimates for Japan as a whole, the authors had also gathered and organized vast amounts of prefectural data. These data, sources, and materials, archived at the Research Centre for Information and Statistics of Social Science attached to the IER, greatly shortened the time necessary for obtaining, inputting, and aggregating data on manufacturing output in original sources such as the *Fuken Bussan Hyo*

and *Fuken Tokei Sho*.

That being said, a considerable amount of data entry work remained and, following the tradition of the LTES, this was conducted by research support staff in offices set up for this purpose, namely the Large-Scale Data Archiving and Processing Section, the Asian Historical Statistics Project Office, and the JIP Database Office. We herewith would like to express our thanks to the support staff, above all Yumiko Moriyama.

While the research for this book greatly benefited from the work of our predecessors, we hope that it will also contribute to future research at the IER. For instance, as part of the construction of the Asian Historical Statistics series, the LTES are currently being revised and extended backward, and we believe that the work for the present volume considerably contributes to this task. Whereas GDP estimates for Japan in the LTES go back to 1885, we managed to extend those estimates all the way back to 1874. In addition, we revised the GDP estimates in the LTES from 1890 onward using newly estimated gross value added in the primary and tertiary sectors (see Appendix 2). What is more, the GPP estimates and information on industrial structures for the Meiji period obtained in the present study were employed by Osamu Saito and Masanori Takashima to estimate regional and national GDP in the Tokugawa period (see Appendix 1).

Given that the construction of the database was made possible only through the financial support we received from various public funding bodies, we feel it is incumbent on us to make the database publicly available to the wider academic community. Therefore, the parts of the database that are not already public will be made available on the IER and RIETI websites in due course (see Appendixes 2 and 3 for details).

As is common in academia, we presented preliminary results of our research at various conferences such as the World Economic History Congress and the Asian Historical Economics Conference, at the Science Council of Japan and the International Institute for Advanced Studies, and so forth, and received many valuable comments. We would like to thank participants for their comments, in particular Jeffrey Williamson of Harvard University, Peter H. Lindert of the University of California, Davis, Jean-Pierre Dormois of Sciences Po Bordeaux, Stephen N. Broadberry and Debin Ma of the London School of Eco-

nomics, Myung Soo Cha of Yeungnam University, Noriko Tsuya of Keio University, Hitoshi Tominaga of the University of the Ryukyus, Naofumi Nakamura and Masaki Nakabayashi of the University of Tokyo, Matao Miyamoto and Kenichi Tomobe of Osaka University, and Toshiyuki Mizoguchi, Konosuke Odaka, Etsuro Shioji, Chiaki Moriguchi, and Ryo Kambayashi of Hitotsubashi University.

Finally, we would like to mention that this book is not an edited volume, but the product of close collaboration among all seven authors, so that each of the various chapters and appendixes represents the joint work of several or all of the authors. That being said, each chapter was written under the leadership of one or several authors. The following lists the lead author(s) of each chapter or appendix.

Chapter 1: Ralph Paprzycki, Jean-Pascal Bassino, and Kyoji Fukao
Chapter 2: Jean-Pascal Bassino
Chapter 3: Tokihiko Settsu
Chapter 4: Ralph Paprzycki
Chapter 5: Kyoji Fukao, Tatsuji Makino, and Joji Tokui
Chapter 6: Joji Tokui, Tatsuji Makino, and Kyoji Fukao
Chapter 7: Jean-Pascal Bassino and Kyoji Fukao
Appendix 1: Masanori Takashima
Appendix 2: Tokihiko Settsu, Kyoji Fukao, and Jean-Pascal Bassino
Appendix 3: Tatsuji Makino
Appendix 4: Tatsuji Makino and Joji Tokui

March 2015

Kyoji Fukao
Jean-Pascal Bassino
Tatsuji Makino
Ralph Paprzycki
Tokihiko Settsu
Masanori Takashima
Joji Tokui

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Chapter 1

Introduction

Since Kuznets proposed his hypothesis [of an inverted U curve of income inequality] in 1955, economists interested in the problem have spent almost all their energies establishing twentieth-century cross-section evidence to test the hypothesis. Much less work has been devoted to long-run nineteenth-century experience with the Kuznets curve. While American and British nineteenth-century experience seems to confirm the thesis, we need many more inequality histories from continental Europe and elsewhere to better understand the process. In addition, while scholars have lavished considerable attention on documenting inequality experience, they have spent far too little time modelling the process, and thus rarely offer explanations for the presence or absence of the Kuznets curve.

I am sure that Simon Kuznets would have shared my hope that the next thirty years of historical scholarship will try to augment our understanding of the determinants of inequality in all of these directions.

Jeffrey F. Williamson (1991: 75)

1.1 Motivations and major characteristics of this study

The first non-Western nation to achieve industrialization and sustained, and often rapid, economic growth in the late 19th and early 20th century, Japan occupies a unique place in the economic history of Asia. Moreover, the country provides an interesting case of balanced

regional economic development, which contrasts with a number of other OECD countries. In the 20th century, Japan experienced steady economic growth with quite a homogenous rise in living standards across all prefectures.

Regional patterns of development matter both because of the social costs of regional imbalances and because of the gains resulting from a smooth process of economic development in the entire national territory. National averages of economic indicators such as income per capita mask potentially large differences in living standards across regions. Such regional inequality, in turn, has a variety of implications in terms of economic equity and welfare, growth, and development. For instance, although national indicators may suggest that a country had reached a certain level of economic development and hence welfare at a particular point in time, it is possible that pockets of poverty remained until much later than national averages imply.

A key focus of the debate on income inequality has been the hypothesis by Kuznets (1955) that inequality increases in the early stages of modern economic development, eventually reaches a peak, and then begins to fall as economic development continues. Thus, if one were to trace the relationship between inequality on the vertical axis and average income on the horizontal axis, it would form an inverted U. This process is connected with the issue of economic "catch up" or convergence. While Kuznets' main focus was personal income inequality, the transformation of a predominantly agrarian economy into an industrial one usually implies a reallocation of labor from low-productivity agricultural to high-productivity manufacturing activities and a geographic concentration of manufacturing in a relatively small part of the territory. Personal and regional inequality are therefore intertwined. However, due to the lack of data, regional patterns of development in Japan from the early Meiji era (Meiji era: 1868-1912) to the immediate post-World War II period remain understudied.

The broad pattern of Japanese economic development from the Meiji Restoration in 1868 to the high speed economic growth of the early 1960s is well documented at the national level—not least thanks to the efforts of scholars at Hitotsubashi University, who produced the Long-Term Economic Statistics (LTES) of Japan. This 14-volume series edited by Kazushi Ohkawa, Miyohei Shinohara, and Mataji

Umemura includes annual series of production and expenditure for the different sectors of the economy, and on the basis of these results, they constructed estimates of historical national accounts starting in the late 19th century.[1] However, the authors of LTES series essentially focused on estimates at the national level.

By contrast, annual series of national accounts at the prefecture level are available from 1955 only. Produced by the Japanese administration to identify spatial inequality and its determinants, these series provided information of critical importance to decision makers in devising policies explicitly aimed at maintaining low levels of regional income inequality through public investment in education and infrastructure. These policies proved highly effective in compensating for the concentration of economic activity and labor—and the resultant higher income—in the main urban centers along the Pacific coast, which benefited from agglomeration effects. Partly as a result of these policies, Japan has been characterized by low levels of regional inequality in the second half of the 20th century and up to the present. The country did not suffer from the sort of north-south regional divide that has plagued the economic development of Italy and Spain, where one third of the country remains stuck in a middle-income trap with well-known negative external effects on well-being in a context of dysfunctional institutions. Japan also avoided the fate of countries such as Belgium, Germany, and the United States, where regional divides were reversed in the late 20th century through the decline of once-prominent industrial centers, leading in some cases to the appearance of rust belts, which again were associated with negative externalities and high social costs. Finally, although agglomeration effects have resulted in the concentration of high value added activities in the national capital, Japan does not suffer to the same degree as Britain and France from the negative consequences of these effects.

That being said, however, relatively little is known about regional income inequality in Japan before 1955 and why income inequality in Japan after 1955 has been relatively low. Against this background, the aim of the research project that resulted in the production of this volume has been to estimate historical national accounts for Japan at the prefecture level (47 prefectures) for six benchmark years in the late

[1] Ohkawa, Takamatsu, and Yamamoto (1974); Ohkawa and Shinohara (1979).

19th and early 20th century (1874, 1890, 1909, 1925, 1935, 1940). The findings led us to further expand the scope of our research and, among other things, include the production of separate estimates for the period 1600–1874 allowing an exploration of regional inequality in early modern Japan (for 14 macro-regions). The prefecture-level estimates that we prepared are, in essence, comparable to the LTES estimates at the national level. These prefecture-level estimates allow us to assess the degree of regional inequality in the early Meiji period and its evolution before World War II. Furthermore, they make it possible to investigate the determinants of regional inequality and convergence. A vast body of literature, which we discuss in the following sections, has developed to examine whether such convergence can indeed be observed and what factors may be contributing to (or preventing) it. We find that regional sector-level productivity differences and regional industrial structures, coupled with migration across prefectures, played an important part in shaping inequality across Japanese regions from the end of the 19th century up to the present. For the post-World War II period, for which more detailed data are available, we find that prefectural differences in capital-labor ratios and total factor productivity (TFP) declined, thus contributing to regional income convergence.

Conventional neoclassical growth theory suggests that regional convergence is driven primarily by diminishing returns to capital. Although this mechanism may be an important element in the process, the literature on regional inequality and convergence suggests that the reality is considerably more complex and that a variety of factors—such as institutional idiosyncrasies, agglomeration or contiguity effects, and the external environment, in particular technology shocks, changes in public policies, and wars—contribute to convergence (or divergence). Given the length of the period covered in our study, which includes the wholesale transformation of Japan's economy and society from a rural, agricultural to an urban, post-industrial one, as well as complete devastation during and reconstruction after World War II, such factors clearly played an important role in shaping trends in regional inequality in Japan. We try to discuss some of these factors whenever possible; however, space constraints prevent us from a more systematic examination of the role of institutions, spatial effects, and exogenous changes in the environment, and we leave these issue

for the future. We also recognize that it would be useful to link the dynamics of macroeconomic variables at the prefecture level with evidence based on microeconomic data in order to reach a better understanding of the process of economic transformation at the regional level during the early phases of Japanese industrialization.[2]

Preceding studies investigating the evolution of regional inequality in Japan in the 20th century have tended to find that it followed an inverted U curve over time (Barro and Sala-i-Martin, 1992b). We examine this issue on the basis of our estimates of per capita gross prefectural product (GPP) for the six benchmark years from 1874 to 1940 and existing data for the period from 1950 onward. In doing so, we are able to analyze for the first time how regional income inequality in Japan evolved from a very early stage of economic development. We find that regional inequality in Japan, like in most Western countries for which similar analyses are available, did indeed follow an inverted U curve—that is, regional income inequality first increased in the early stages of industrialization in the late 19th century, peaked sometime during the first half of the 20th century, and then rapidly decreased during the high-speed growth era in the post-war period. What is notable, however, is that regional income inequality—even at its peak—was relatively low. Moreover, the degree of regional inequality in the period 1600–1850 was around the same as in 1874 and hence also comparatively low.

Taking the overall developments in regional income inequality since 1874 as our point of departure, we examine the factors underlying these developments. Specifically, the major characteristics of our study can be summarized as follows:

- We analyze long-term changes in regional income gaps. The main focus of the volume is on the period 1874 to 2008 using prefectural data, but we also provide regional estimates for 14 territorial units from 1600 to 1874.
- We analyze the evolution of income gaps across regions from the perspective of productivity, industrial structure, and domestic

[2] Studies based on microeconomic data or micro-level studies, such as Nakamura (2010) and Tanimoto (1998), in particular have the advantage of discussing the role of institutions in this process.

migration.

- We also take advantage of the availability of high-quality data for the post-WWII period to analyze the role of changes in the capital stock and TFP in addition to sectoral labor productivity. For the period after 1970, we further take into account the evolution of prefecture- and sector-level human capital stock and TFP, and we examine whether migration resulted in a brain drain from poorer to wealthier prefectures.

While our study focuses squarely on Japan, we hope that it will add breadth and depth to the burgeoning literature on regional development worldwide. We think that it may also be relevant for the analysis of regional patterns in present-day developing economies such as China, India, and Indonesia, which are currently experiencing a rising trend in income inequality across regions (Milanovic, 2005). The following sections provide an overview of the literature relating to issues addressed in this study as well as an outline of the remainder of the volume.

1.2 Regional inequality in the 19th and 20th centuries, and the Kuznets curve

A key point of interest in the study of economic development has been the impact of such development on inequality in income across individuals or households as well as spatial units such as countries or regions within countries over time. Inequality matters not only because of its implications for individuals' well-being, which—after all—is what economic development is all about, but also because of its potential effects on the growth and development process itself through the inefficient use of resources. For instance, extreme income inequality across individuals may negatively affect access to health care, education, and finance for the poor, preventing the accumulation of human capital and stunting entrepreneurial initiative. The same argument applies in terms of inequality across spatial units, unless resources are perfectly mobile, which even within countries is rarely the case. Thus, persistent high spatial inequality may potentially slow the growth and development of the economy overall.

Against this background, trends in inequality over time—both in

historical perspective and in the more recent past—have been the subject of considerable academic interest. While Kuznets set out his hypothesis as an argument rather than a formal theory and was rather tentative about it, it has subsequently been formalized.

Debate on the hypothesis has been most vigorous in the development literature, focusing on individual income inequality at the national level rather than inequality across spatial units. It rapidly gained a substantial following, so that at one point, in the 1970s, it was widely accepted as "fully confirmed" (Oshima, 1970) and an "economic law" (Robinson, 1976). Much of the early evidence supporting the Kuznets hypothesis, however, was based on the analysis of cross-country data, which subsequent studies have shown to be misleading because of omitted country-level effects; for instance, it has been widely observed that the purported pattern tends to disappear once controls for Latin American countries—middle-income countries characterized by high inequality—are included (Fishlow, 1995; Bruno, Ravallion, and Squire, 1998; Deiniger and Squire, 1998). Given that the Kuznets hypothesis refers to an intertemporal relationship, a number of researchers have therefore used panel data and estimated the relationship between inequality and income controlling for country-specific effects. The results indicate that while for some countries, an inverted U-shaped relationship can be observed, for others, there was no significant relationship, and for yet others, the relationship was significant but contrary to the Kuznets hypothesis (e.g., Deiniger and Squire, 1998).

On the other hand, in the economic history literature, focusing not on the recent experience of developing countries but on the historical experience during the 19th and early 20th century of now-developed countries, there is considerable support for an inverted U relationship regarding individual income inequality in the economy over the course of industrialization. Given that the large majority of industrialized countries experienced falling inequality for much of the 20th century (see, e.g., Lindert and Williamson, 1985; Kaelble and Thomas, 1991), support for the Kuznets hypothesis has mainly hinged on evidence for the upward-sloping part. Although data on individual income inequality for the 19th century are not very reliable, studies on Britain (Williamson, 1985), the United States (Williamson and Lindert, 1980), Germany (Dumke, 1991), Sweden (Söderberg, 1991), and Belgium (Schol-

liers, 1991) find evidence of increases in inequality in these countries during this period. On the other hand, according to Acemoglu and Robinson (2002), evidence from Norway and the Netherlands indicates monotonically declining inequality from the mid-19th century.

However, even where an inverted U curve in individual inequality can be observed, it was not necessarily the mechanism assumed in the Kuznets hypothesis, i.e., intersectoral migration, that was the driving force underlying changes in inequality. With regard to Britain and the United States, Polak and Williamson (1990: 16-17), for example, observe that

> [c]hanges in earnings inequality are explained primarily by changes in the structure of pay rather than employment shifts from occupations with low skill content to those with high. While skills may well have become less equally distributed in the early 19th century, it was the inflation in the premium on those skills, a relative scarcity of those skills, and a relative glut of unskilled labor that did most of the work in augmenting earnings inequality [...] before the 1860s.

Conversely, one of the explanations for the turning point in the British Kuznets curve in the 1860s is that "skill accumulation finally began to catch up with the skill scarcities created during the industrialization surge in the first half of the nineteenth century" (Williamson, 1991: 74).

A notable development in this context is that individual inequality has been rising in many of the advanced industrialized economies since the 1970s, which has been linked to the impact of globalization and technological change on unskilled wages and the net return on capital, with the latter affecting the income of owners of capital (see, e.g., Williamson, 1996; Atkinson, 2003). This reversal indicates that the inexorable trend toward greater equality suggested by the Kuznets hypothesis is not a foregone conclusion even in economies such as the United States and Britain, where the hypothesis does appear to hold for the period of industrialization. Rather, together with the rather mixed evidence on developing countries, the reversal indicates that the distribution of income is a highly complex phenomenon that is determined by a wide variety of factors, including many which for the

sake of brevity have not been discussed here, such as tax and social transfer policies. Therefore, while the Kuznets hypothesis appears to capture some important aspects of the evolution of individual income inequality over time, the mechanism originally assumed by Kuznets is only one of the forces potentially giving rise to an inverted U curve, and other factors may mean that it does not arise at all. Consequently, it would be surprising if a single explanation such as the Kuznets hypothesis sufficed for all countries and all periods.

Compared with the study of individual income inequality at the national level, historical research into *regional* inequality within countries has a relatively short pedigree, largely due to the lack of data. Probably the first study on the long-term trend in regional inequality is that by Easterlin (1960) on the United States, which since the turn of the millennium has been followed by a spate of studies on European countries. In these studies, too, a key point of interest has been whether inequality followed an inverted U curve during the course of economic development. Williamson (1965), for example, hypothesized that this would be the case, suggesting that, in the United States, structural change and specialization in the early stages of industrialization went hand-in-hand with rising regional inequality, followed by a decline as a result of further structural change and integration reflecting increasing capital movements and internal migration.

Evidence for countries for which regional data are available confirm that such a pattern can indeed be observed in many, though not all, cases. For the United States, it is found that regional incomes generally diverged from 1840 to around 1900 and then started to converge (Easterlin, 1960; Williamson, 1965; Kim, 1998). Based on a detailed analysis of regional data, Kim (1998) argues that the increase in regional inequality during the 19th century can be largely explained by increasing dissimilarities in factor endowments as manufacturing became more important, resulting in growing regional specialization in agriculture and manufacturing that led to a divergence in industrial structures and hence regional income per capita. On the other hand, the decline in regional inequality from the turn of the 20th century reflects growing similarities in industrial structures as differences in land and resource endowments became less important and regional factor endowments converged. The latter trend partly reflects the growing mobility of factors of production, resulting in a convergence

of capital–labor ratios, an aspect that will be discussed in greater detail below.

Other countries that experienced first an increase and then a decrease in regional inequality include Britain (Crafts, 2005), France (Combes et al., 2011), Italy (Felice, 2011), Spain (Martínez-Galarraga, Rosés, and Tirado 2013; Rosés, Martínez-Galarraga, and Tirado, 2010), and Portugal (Badia-Miró, Guilera, and Lains, 2012). However, whereas the turning point for the United States is observed around 1900, that for the European countries followed a few decades later, in the early and mid-20th century.[3] This is also what we found for Japan (see Chapter 2). On the other hand, no inverted U curve is observed for Sweden; instead, despite some upswings during certain periods, inequality generally followed a downward trend during the period 1860–1980 (Enflo and Rosés, 2014). Thus, Sweden is one of the very few countries to have experienced no increase in regional inequality. A further noteworthy finding is that in many of these countries—both those where an inverted U curve can be observed and those where this is not the case—the trend in regional convergence appears to have stalled or even reversed since around 1980. This is the case in Britain (Crafts, 2005), France (Combes et al., 2011), Italy (Felice, 2011), Sweden (Enflo and Rosés, 2014), and also Japan, as will be seen later. This cessation of *regional* convergence more or less coincides with the reversal in *individual* income convergence mentioned above.

In sum, the fact that an inverted U curve in individual or regional inequality over the course of industrialization can be observed for some countries but not others suggests that the Kuznets hypothesis may capture some elements of the transition to modern economic

[3] A complicating factor in this context is that due to data constraints, in some of these studies, including those on Britain and Spain, divergence and convergence are measured using an income approach, while in other studies, in particular the studies on the United States and Italy, a production approach is adopted and the analysis is based on estimates of regional value added. District-level value added and income series cannot be expected to be identical. In addition, the different components of income do not necessarily evolve in the same manner. For example, in Spain wages converged in the late 19th and early 20th century (Rosés and Sanchez-Alonso, 2004), whereas total income diverged (Rosés, Martínez-Galarraga, and Tirado, 2010).

growth. At the same time, however, the mechanism assumed in the hypothesis may be only one of the links between inequality and growth, and how inequality evolves over time is likely to be determined by a host of overlapping country-specific dynamics. For example, Enflo and Rosés (2014) argue that the absence of regional divergence in per capita GDP in Sweden's early phase of industrialization (1860–1910) to a large extent is explained by the role of migration. Thus, whether an increase in regional inequality in the early stages of modern economic growth giving rise to an inverted U curve can be observed is an empirical matter rather than an inescapable concomitant of the development process.

1.3 Regional convergence and its determinants

As the debate surrounding the Kuznets hypothesis highlights, economic growth and development can be accompanied by an increase or decrease in income disparities across countries or regions, that is, divergence or convergence. Economic theory does not provide unambiguous predictions about whether per capita income levels across countries or regions necessarily can be expected to diverge or converge over time, and there is a vast literature on both the theory and empirics of the issue. The purpose here is to provide a brief outline of the theoretical concepts relevant to the analysis in the following chapters and to discuss the findings of empirical studies on regional convergence in Japan. Subsequent subsections then look in greater detail at aspects of this theoretical debate that are particularly relevant to our analysis of developments in Japan.

As a starting point of the discussion, it is useful to provide a simple definition of convergence: convergence, essentially, refers to a tendency for regional income disparities to fall over time as poorer economies in a given sample grow faster than richer economies. As highlighted in the survey by de la Fuente (2002), the growth literature identifies three key mechanisms that may lead to convergence or divergence: decreasing or increasing returns to scale in capital, technological progress, and structural change. Decreasing returns to scale mean that output increases less than a proportional change in capital, resulting in a decline in the marginal productivity of capital. This, in turn, lowers the incentive to save and the contribution to growth of a

given volume of investment, resulting in a slowdown in growth over time. Thus, poorer economies with lower stocks of capital will grow faster than richer ones as they have a greater incentive to save and enjoy faster growth with the same rate of capital investment, resulting in convergence. Turning this neoclassical assumption of decreasing returns to scale on its head and assuming increasing returns instead, as in the endogenous growth literature, yields the opposite prediction.

Technological progress may similarly work in the direction of either regional convergence or divergence. If economies differ in their efforts to generate or adopt technologies and, moreover, the accumulation of knowledge is not subject to diminishing returns, then their growth rates will also differ, so that technological progress could be a divergence factor. However, technical knowledge also has important public good properties, meaning that lagging economies do not have to reinvent the wheel and may be able to grow more quickly than leading economies through technological catch-up. Especially when considering spatial units within countries, where institutional barriers and differences in absorptive capacity are likely to be less severe than across countries, technology diffusion may play an important role in convergence.

The third mechanism identified in the growth literature through which divergence or convergence may occur is structural change, that is, the reallocation of factors of production across sectors of the economy. This mechanism is closely related to the one underlying the Kuznets hypothesis and refers to the fact that as economies grow, productive resources are typically reallocated from agriculture, where productivity is low, to the manufacturing and service sectors, where productivity is higher, resulting in an increase in average productivity. Thus, at the early stages, there may be divergence as leading economies get a head-start in the transition from agriculture to manufacturing and services, but this will be followed by a period of convergence as the sectoral composition of lagging economies catches up with that of their leading counterparts.

Another mechanism that may contribute to convergence that is often not considered in the growth literature is migration.[4] Typically, migration takes the form of the movement of labor from poorer, less capital-intensive economies to richer, more capital-intensive ones. In the standard neoclassical framework, such labor movements affect the

capital-labor ratios in both the lagging and the leading economies, working toward an equalization of these ratios and hence convergence. However, as discussed in greater detail below, relaxing or abandoning the assumptions of the standard neoclassical framework results in effects that can offset or amplify the impact of this mechanism, so that the theoretical predictions are ambiguous. For instance, if labor is not homogenous, as assumed in the standard framework, and migrants are better educated (and hence more productive) than non-migrants, migration may work in the direction of divergence.

Having considered the key mechanisms that may contribute to convergence or divergence across countries or regions, it is helpful to briefly discuss different concepts of convergence. Going back to Barro and Sala-i-Martin (1990, 1992a), concepts that have featured prominently in the literature are those of σ-convergence as well as unconditional and conditional β-convergence. The first of these, σ-convergence, refers to whether the dispersion of income per capita—measured, for example, by the standard deviation of its logarithm, by the coefficient of variation, or by the Theil index—decreases over time.

The concept of β-convergence, on the other hand, is closely tied to the neoclassical growth model and focuses on the coefficient that is obtained by regressing the growth of economies' per capita income over a certain period of time on the initial level of per capita income. A negative β-coefficient indicates that economies with a lower initial level of per capita income grow more rapidly than economies with a higher initial level, and the size of the coefficient indicates the speed of convergence. Further, neoclassical theory distinguishes two types of convergence, unconditional and conditional convergence. Convergence is said to be absolute or unconditional when it is assumed that economies all converge to the same steady-state growth rate. Unconditional convergence is more likely to be found when testing the model for regions of the same country, since they share similar legal and other institutions, levels of education and technology, etc. On the other hand, convergence is said to be conditional when it is assumed that each

[4] Only a few empirical studies, discussed below, consider the impact of migration on living standards in the receiving regions. Since the mechanism is not essentially different from the one at play in international migration, we can refer to this literature (e.g., Friedberg and Hunt, 1995).

economy converges to its own steady state, which, however, depends on its "fundamentals." Some form of β-convergence is a necessary condition for σ-convergence. However, as highlighted by a number of scholars (e.g., Young, Higgins, and Levy, 2008), β-convergence is not a sufficient condition for σ-convergence, since income dispersion may temporarily increase despite β-convergence if the initial level of inequality is below its steady-state value (as determined by the distribution of fundamentals) or as a result of random shocks. In fact, with conditional β-convergence, where each economy converges only to its own steady state, a high degree of inequality could persist even in the long run, since economies may differ considerably in their fundamentals.

Turning to the empirical evidence and concentrating on regional convergence within countries, there is considerable evidence in favor of both σ-convergence and β-convergence. For instance, all of the studies referred to in the discussion of the Kuznets hypothesis in the previous section, using the coefficient of variation, the Theil index, or a similar measure,[5] find a long-run trend of σ-convergence (albeit one that was preceded by a period of initial divergence in many countries and renewed divergence in the last decades of the 20th century in some). Similarly, Barro and Sala-i-Martin (2004), using the cross-sectional standard deviation of the log of regional per capita personal income or per capita GDP, suggest that a clear long-term trend of σ-convergence can be observed in the United States, Japan, Germany, France, the UK, Italy, and Spain.

Barro and Sala-i-Martin, who introduced the concepts of σ- and β-convergence (Barro and Sala-i-Martin, 1991), also estimated regional convergence equations for the same countries as well as for Canada and 90 European regions (summarized in Sala-i-Martin, 1996), and obtained significant estimates for the convergence coefficient, β, in all cases. They argue that "[o]ne surprising result is the similarity of the speed of β-convergence across data sets. The estimates of β are around 2-3 percent in the various contexts," and that this "slow speed of convergence implies that it takes 25-35 years to eliminate one-half of an initial gap in per capita incomes" (Barro and

[5] Felice (2011), for instance, uses the weighted coefficient of variation proposed by Williamson (1965).

Sala-i-Martin, 2004: 496). Following in their footsteps, numerous other studies finding evidence of β-convergence have been conducted, including, for example, Evans and Karras (1996) and Higgins, Levy, and Young (2006) on the United States, Persson (1997) on Sweden, Cardenas and Ponton (1995) on Colombia, and Kırdar and Saracoğlu (2007) on Turkey.

However, both the "uniform" rate of β-convergence of 2–3% per annum and the concept of β-convergence more generally have been challenged by a number of scholars. Hall and Ludwig (2006), for example, find no evidence of β-convergence in post-unification Germany and argue, moreover, that capital fails to move between regions in the pattern assumed by the convergence hypothesis. Similarly, Gezici and Hewings (2004) find no evidence of β-convergence (or, for that matter, σ-convergence) for Turkey, while for the Czech Republic, Mazurek (2013) finds that there has even been σ- and β-divergence. More general criticisms of the concept of β-convergence take various forms. Quah (1993), for example, argues that the concept of β-convergence provides no information on how poorer economies are catching up with richer ones, while Bernard and Durlauf (1996) highlight that convergence regressions assume that all economies in the sample follow the same rate of convergence. Further, Friedman (1992) and Quah (1996) suggest that a negative β does not necessarily imply a convergence of growth rates but rather regression towards the mean and that the concept of β-convergence confuses average with cross-distribution dynamics. Both therefore argue that the true test of convergence is a decline in the variance among individual observations, that is, σ-convergence, which directly addresses whether the distribution of income across economies—regions in our case—is becoming more equitable.[6]

In line with other historical studies on regional development, our main interest is in the trend in spatial inequality over time, the factors underlying such inequality, and the mechanisms through which poorer regions catch up with richer ones. For this reason, we will not enter into the debate on β-convergence in our analysis and instead focus on σ-convergence using the coefficient of variation as well as other mea-

[6] Other scholars criticizing the concept of β-convergence include Johnson (2000), Rassekh, Panik, and Kolluri (2001), and Linden (2002).

sures of regional income distribution such as the comparison of quantiles. However, we also use information about the correlation between initial per capita GDP and per-capita GDP growth (β) when we analyze the relationship between initial per capita GDP and factor input growth. That being said, most of the relatively little research there is on regional growth and convergence in Japan has focused on β-convergence, kicked off by the study by Barro and Sala-i-Martin (1992b), and we will discuss the results of this and subsequent studies following in their footsteps in greater detail below.

1.4 Structural change and regional convergence

One of the potential convergence mechanisms identified in the growth literature, as mentioned above, is that of structural change through the reallocation of factors of production across sectors of the economy. The brief discussion earlier, for example, suggested that as economies grow, productive resources are typically reallocated from less productive sectors, such as agriculture, to more productive sectors such as manufacturing and services, so that at the early stages of development, there may be divergence as leading economies get a head-start in the transition from agriculture to manufacturing and services, but this will be followed by a period of convergence as the sectoral composition of lagging economies catches up with that of their leading counterparts.

Such a pattern implies that, over the course of development, an inverted U curve in terms of regional specialization should be observed. Studies covering a sufficiently long period of time suggest that such an inverted U curve pattern can indeed be found. Using data for the period 1860–1987, Kim (1995), for example, shows that in the case of the United States, regional specialization increased until the 1930s and then started to fall. Similarly, for Spain, Rosés, Martínez-Galarraga, and Tirado (2010), using data for 1860–1930, find that regional specialization steadily increased from 1860 to 1920, before falling again in the following decade. Further, they argue that this increasing regional specialization was the main cause of inequality growth during the second half of the 19th century, while the reverse holds for the first third of the 20th century.

While these patterns may give the impression that there is a rela-

tively straightforward relationship between structural change, growth, and regional inequality, the growth literature shows that this is far from the case. That structural change through resource allocation across sectors can make an important contribution to growth has long been recognized. Kuznets (1955), for example, focusing on the shift of labor from agriculture to manufacturing and services during roughly the first half of the 20th century in a range of (mainly developed) countries, suggests that in most countries the contribution to growth in per capita income was significant, accounting for 10–30%. A host of other studies, summarized in Syrquin (1984), employing a variety of approaches that, for example, also take the reallocation of capital into account and focus on other measures such as TFP growth similarly show that structural change can make an important contribution to growth.

However, as highlighted by McMillan and Rodrick (2011), for example, it is by no means inevitable that structural change contributes to productivity growth. Comparing the impact of structural change on productivity growth in Asia, Africa, and Latin America, they find that in the latter two regions, labor has moved in the "wrong" direction, since rationalization of manufacturing industries has meant that displaced workers have ended up in less productive activities. McMillan and Rodrick (2011) argue that one important factor underlying the differential impact of structural change is that African and Latin American countries are well endowed with natural resources and primary products, and that integration with the world economy through globalization reduced incentives to diversify towards modern manufacturing and reinforced specialization in primary sectors, where labor productivity may be high, but which have limited capacity to generate employment.

Along similar lines, but focusing explicitly on regional disparities, Giannetti (2001) examines the link between regional specialization and inequality in per capita income in the European Union during the 1980s and early 1990s, highlighting that although integration in the European Union during this period was accompanied by a decrease in the cross-country dispersion of per capita GDP, it went hand-in-hand with an increase in within-country regional disparities. Specifically, empirically testing the implications of a two-country two-sector model with spillovers, she finds that regions specialized in advanced sectors

at the beginning of the observation period became more similar in terms of per capita income, while regions specialized in traditional sectors lagged, creating harsher disparities within countries.

These studies indicate that structural change does not *necessarily* contribute to growth and convergence. Further, Timmer and de Vries (2009) suggest that more important than the reallocation of resources across sectors in explaining economic growth is the contribution of productivity increases within sectors. Specifically, using a dataset of 19 Asian and Latin American countries covering the period 1950–2005, they find that productivity increases within sectors accounted for 75–79% of growth, leaving only 21–25% for the expansion of more productive sectors. Needless to say, sectors differ in terms of labor productivity levels and growth, which in turn are the result of differences in capital intensity and the pace of capital deepening, and differences in TFP growth (Harberger, 1998). This means that in order to fully assess the mechanism linking structural change, growth, and regional inequality, it is necessary to take these factors into account.

1.5 Migration and regional convergence

As highlighted earlier, another factor potentially playing a major role in regional convergence or divergence is migration. However, economic theory again does not provide unambiguous predictions on the impact of migration on regional inequality. In a basic neoclassical framework, which assumes diminishing returns to labor and capital, one would expect migration to reduce spatial inequality as capital and labor move in opposite directions and both contribute to a reduction in regional disparities in capital-labor ratios and income per capita. Specifically, one would expect labor to move from low income, less capital-intensive regions to high income, more capital-intensive regions, so that—all else being equal—capital intensity and labor productivity increase in the former and decrease in the latter, thus bringing the capital intensities of sending and receiving regions closer. This means that outward migration raises the rate of growth in income per capita and inward migration lowers it, resulting in convergence in income per capita (e.g., Polese, 1981; McCann, 2013).

However, once the assumptions of this standard framework, such as a homogenous labor force, are dropped and the characteristics of

migrants, such as their youthfulness, entrepreneurship, and skills are taken into account and, moreover, a dynamic perspective is adopted, the implications of migration for income growth and convergence are less straightforward. For instance, there is widespread evidence that migration tends to be skill-selective, that is, migration propensities tend to rise with education and other skill indicators such as wages (e.g., Greenwood, 1997, and references therein; Borjas, Bronars, and Trejo, 1992), giving rise to a potential "brain drain" in sending regions. Further, given that it is typically the young that migrate—Greenwood (1997), for example, observes that migration propensities frequently peak in the early twenties—, migration also affects the age composition and hence the age-related human capital composition of sending and receiving regions (Shioji, 2001). While the first mechanism potentially contributes to divergence among regions, the latter is likely to contribute to convergence (as younger, less productive workers move from lagging to leading regions). Empirical results for Japan by Tokui, Makino, Kodama, and Fukao (2013b) suggest that labor force migration by the young indeed results in labor outflows from prefectures with lower labor quality (which tend to be the poorer prefectures) and labor inflows to prefecture with higher labor quality (typically the richer prefectures); however, because it is not only the highly educated that migrate, but also junior high and high school graduates that migrate in the same direction, the impact on differences in labor quality appears to be negligible.

Further, both the "brain drain" effect and the effect on the age and hence human-capital composition of sending and receiving regions also have dynamic implications. In the context of the literature on international migration, a number of scholars have argued that the "brain drain" effect may be offset by the fact that migration prospects may in fact foster human capital formation in the sending regions by encouraging enrolment in education (e.g., Mountford, 1997; Kanbur and Rapoport, 2005). In line with this argument, Suzuki and Suzuki (2007), focusing on internal migration in China, find that the direct brain drain effects of net interprovincial migration are mitigated by the effect on new human capital investment, while Li et al. (2012), although their analysis does not examine the role of migration, find that, from 1996 to 2008, per capita human capital in China grew faster in rural than in urban areas. Similarly, the effect of migration on the

composition of age-related human capital also has a dynamic dimension if one takes into account that young migrants accumulate skills over time and older cohorts in the sending regions retire.

But the implications for the distribution of human capital are not the only reason why the impact of migration on regional disparities is difficult to predict. Rappaport (2005), for example, using an extended neoclassical growth model, shows that if the disincentive effects of population flows on capital formation in sending regions are taken into account, the direct effect of population flows in the simple equalization mechanism just described may be offset. Further, leaving the neoclassical framework behind, if agglomeration externalities are important sources of growth (see, e.g., Krugman, 1991b; Fujita, Krugman, and Venables, 1999; Venables, 2005; Henderson and Wang, 2005), then migration to, and the concentration of economic activity in, richer areas may stunt agglomeration externalities in lagging regions and reinforce them in leading regions, thereby offsetting any convergence due to other mechanisms.

Given the conflicting mechanisms, it is perhaps not surprising that studies on the effect of internal migration in the neoclassical growth model have yielded diverse results. For example, Barro and Sala-i-Martin, in their various studies on β-convergence in the United States, Japan, and a number of European countries (summarized in Barro and Sala-i-Martin, 2004: table 11.7) find that the impact of internal migration on per capita income growth across regions is not statistically significant once instrumental variables accounting for the endogeneity of migration are included. Moreover, the effect on the estimated β is also inconclusive. Other studies finding no significant or a negligible effect of migration on convergence include Gezici and Hewings (2004) for Turkey and Cardenas and Ponton (1995) for Colombia. In contrast, Persson (1997) found that in the case of Sweden, migration had a positive impact on the speed of convergence, although its role in overall convergence was small, while Kırdar and Saracoğlu (2007), also focusing on Turkey, do find a significant negative effect of migration on growth rates (i.e., a positive effect on convergence). Similarly, Martin-Mayoral and Gardimartin (2013) suggest that migration made a positive contribution to convergence across Spanish regions in the period 1955–2008, while Piras (1993) obtained similar results in his study on convergence across Italian regions that takes

human capital into account. Moreover, using the same methodology taking human capital into account and focusing on the period 1980–2000, Østbye and Westerlund (2007) find that the effects differ in Norway and Sweden. Given these conflicting results, even for the same country (Turkey), Ozgen, Nijkamp, and Poot (2010) conducted a meta-analysis of twelve primary studies containing 67 estimates and conclude that the overall effect of net migration on growth in real per capita income is positive (i.e., working in the direction of divergence), but small. In sum, the evidence on the link between migration and β-convergence is decidedly mixed.

In contrast, a number of studies focusing not on β-convergence but on σ-convergence using a variety of approaches and considering per capita GDP or wages do suggest that migration may have played a substantial role in spatial convergence. Taylor and Williamson (2007), for instance, employ a counterfactual simulation approach to examine international (rather than within-country) convergence during the age of mass migration in the period 1870–1910 from the Old World to the New World. They suggest that in the absence of migration real wage dispersion would have increased by 7% instead of decreasing by 28%, while per capita GDP dispersion would have declined by only 9% instead of the actual 18%. They therefore conclude that "[t]he convergence power of free migration, when it is tolerated, is likely to be substantial given the late-nineteenth century evidence" (Taylor and Williamson, 2007: 49). Turning to studies on within-country convergence, Enflo and Rosés (2014), focusing on regional inequality in Sweden between 1860 and 2000, decompose convergence in labor productivity into within-industry convergence, labor reallocation effects, and between-industry convergence. They find that during the period 1860–1910 regional convergence in labor productivity in agriculture and services as well as the reduction of productivity differences across sectors made the largest contribution to convergence overall and argue that these developments were closely related to migration. On the other hand, the convergence witnessed during the period 1940–1980, they argue, was largely due to labor reallocation from declining industries and regions towards growing industries and regions, encouraged by government policy. Finally, Enflo, Lundh, and Prado (2014), also focusing on Sweden (but only from 1860 to 1945), examine regional wage differentials and, using the coefficient of variation,

find that migration contributed to wage convergence especially in the latter part of the 19th century, since migration flows went from backward, low wage regions, to more dynamic (more industrial, more urban) high wage regions.

1.6 Convergence of total factor productivity and capital–labor ratios

As highlighted in Section 1.3, yet another factor playing a potentially important role in driving convergence or divergence is technology in the broadest sense, that is, the efficiency with which factors of production are used, and which is measured by total factor productivity (TFP). Empirically, TFP is derived as a residual (for example, in the case of cross-regional comparisons, TFP is derived as differences in labor productivity minus differences in the contribution of the capital–labor ratio), so that TFP is often called the measure of our ignorance. However, micro- and macro-level studies have shown that TFP is closely related with firms' innovation activities such as research and development (R&D), with the international competitiveness of firms, and with resource allocation in the economy. TFP therefore is typically regarded as a measure of the technology level and efficiency.

Although derived as a residual, TFP, which per definition together with the (physical and human) capital–labor ratio determines labor productivity, is a key determinant of (differences in) per capita GDP. For example, studies decomposing labor productivity difference across countries show that TFP differences tend to be more important than differences in capital–labor ratios. In a survey of the data, Caselli (2005) finds that only about one third of the cross-country variation in labor productivity can be attributed to differences in (physical and human) capital (on this issue, also see Klenow and Rodriguez-Clare, 1997).

Empirical studies show that an important part of the large differences in TFP across countries can be attributed to institutional differences (see, e.g., Hall and Jones, 1999; Acemoglu, Johnson, and Robinson, 2005). For this reason, when considering regional TFP differences within the same country, one might expect TFP differences to be less important in explaining regional labor productivity differences than differences in capital–labor ratios, since in most modern economies—

including Japan after the Meiji Restoration—the institutional framework is identical, or at least very similar, across regions. However, this is not necessarily the case, since differences in (physical and human) capital-labor ratios also are likely to be smaller due to smoother capital and migration flows than in an international setting. For instance, using factor input and output data of 28 states in the United States for the period 1840–2000, Turner et al. (2010)[7] find that the share of cross-regional labor productivity variation within the country that can be attributed to differences in (physical and human) capital in the period 1880–2000 was only about one third, almost the same as Caselli's (2005) result in the cross-country comparison.[8] Consequently, convergence in TFP plays a potentially important role in overall convergence in regional per capita income levels.

The empirical evidence on convergence in TFP levels over time is relatively mixed. Starting with cross-country studies, it appears that TFP convergence even among developed countries—i.e., countries with comparatively similar institutional frameworks—is not necessarily a given. On the one hand, Wolff (1991), for example, finds steady σ-convergence in TFP levels among the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) from 1950 to 1979. On the other hand, Inklaar, Timmer, and van Ark (2007) and Fukao et al. (2012) show that major European countries and Japan fell considerably behind the TFP growth observed in the United States from the mid-1990s onward. In the United States, macro TFP growth accelerated mainly because of a substantial increase in TFP growth in the information and communication technology (ICT)-using sectors such as commerce and transportation. In contrast, such an ICT revolution did not occur in the major European countries and Japan. Similarly, Balta (2013) finds that within the Euro area, southern countries' TFP growth lagged well behind that of northern countries during the period 1999–2007.

Turning to the evidence on TFP convergence within countries, studies suggests that this can be more frequently observed. Turner et al. (2010) in their study on the United States, for example, find that although the coefficient of variation of TFP levels across states

[7] For details on their data, also see Turner, Tamura, and Mulholland (2013).

[8] For 1840, they find that this share was about two thirds.

increased substantially between 1840 and 1850, it subsequently followed a declining trend, so that by 1940 it had returned to the level in 1840. Between 1940 and 1950, the coefficient of variation then displayed a sharp drop, before remaining more or less unchanged from 1950 onward. Therefore, the key period of σ-convergence of regional TFP levels in the United States was 1940–1950. Meanwhile, studies on Germany show that after reunification the TFP levels of former East German states partly caught up with former West German states (Keller, 2000; Smolny, 2012).

Understanding the factors that are crucial for technological catch-up, such as R&D, absorptive capacity, human capital, non-R&D intangible investment, inward direct investment, economic institutions, etc., has been the subject of considerable theoretical and empirical research (see, e.g., Benhabib and Spiegel, 2005; Castellacci, 2011; Lee, 2013; and Wolff, 2014). However, no conclusive consensus has been reached, and apart from the studies just mentioned, there is very little empirical research on the mechanisms of convergence of regional TFP levels within countries. That being said, there are several reasons why we would expect TFP convergence within countries to be smoother than TFP convergence across countries. First, as already mentioned, economic institutions tend to be more similar within than across countries. Second, production and supply links among firms tend to be stronger within than across countries, and there is more migration of workers within countries because of smaller differences in economic institutions, language, and culture, as well as the non-existence of regulations on cross-border investment and migration within countries, making technology diffusion easier within than across countries. And third, governments frequently pursue policies to promote TFP in poorer regions through investment in infrastructure and other measures.

Next, let us consider convergence in capital-labor ratios across countries and regions. Evidence suggests that capital-labor ratios among developed countries and among regions in developed countries indeed tend to converge. For example, Wolff (1991) suggests that in the case of physical capital-labor ratios, the coefficient of variation for the G7 countries declined substantially from 1960 to 1979. Further, in their study on the United States, Turner et al. (2010) find that the coefficients of variation for both physical and human capital-labor

ratios declined steadily from 1850 to 2000. Finally, for Germany, Keller (2010) shows that after reunification, former East German states experienced a more rapid increase in their capital-labor ratios than former West German states.

There are few studies on the overall mechanism of convergence in capital-labor ratios across regions within countries. However, as discussed above, in addition to migration from poorer to richer regions, one would also expect capital to flow in the opposite direction, thus contributing to convergence in capital-labor ratios across regions. That being said, in the case of international capital flows, capital frequently moves from poorer to richer countries. This phenomenon is known as the Lucas paradox (Lucas 1990). From a theoretical perspective, there are two possible explanations for this paradox. The first is differences in fundamentals, such as differences in TFP levels or human capital, which result in a lower rate of return on capital in poorer than in richer countries, even though physical capital is scarcer in poorer countries. The second is imperfections in international capital markets, such as default risk and asymmetric information problems. In their empirical study using cross-country data, Alfaro, Kalemli-Ozcan, and Volosovych (2008) found that institutional quality is the most important variable for explaining the Lucas paradox. However, since institutions within countries are very similar, it seems unlikely that there will be substantial capital flows in the "wrong" direction as in the Lucas paradox. Instead, one would expect capital to flow from richer to poorer regions, as standard neoclassical theory suggests.

Of considerable interest in this context is a study by Dekle (1996), who found that in Japan the cross-section correlation between prefectural private savings rates and private investment rates is close to zero and that there were extremely active capital movements between prefectures. Moreover, although richer prefectures had higher savings rate, these were not linked to higher prefectural investment rates. These findings suggest that convergence in capital-labor ratios across regions within countries is indeed smoother than across countries.

In sum, differences in TFP and capital-labor ratios are the main determinant of differences in (regional) per capita GDP differences, with empirical evidence suggesting that differences in TFP in particu-

lar potentially play a very important role. Convergence in one or both of these two factors therefore will work in the direction of convergence in (regional) per capita GDP levels overall. Finally, the theoretical considerations presented here would lead one to expect for TFP and capital-labor ratios to converge more smoothly across regions within a country than across countries.

1.7 Personal and regional inequality in Japan since the late 19th century

Having considered theoretical issues related to income inequality and convergence, and having provided an overview of the patterns observed elsewhere, let us now take a look at the findings of previous studies on inequality, regional growth, and convergence in Japan. Specifically, we will consider findings on both personal and regional inequality as well as their evolution over time.

Starting with personal income inequality, it is noteworthy that at one point, in the 1970s, "Japan was regarded as being the most egalitarian country in the world" (Minami, 2008: 5). However, both before and since then, Japan has been characterized by considerable income inequality and today in fact has one of the highest levels of income inequality in the OECD (Tachibanaki, 2006). Given these extremes, it is useful to have a brief look at developments in personal income inequality in Japan over the period covered in this study.

Relatively few studies examine income inequality in Japan during the period before World War II (or the war itself). However, those that do exist, summarized in Moriguchi and Saez (2008: figure 2), suggest that income inequality, as measured by the Gini coefficient, was already relatively high around 1895 and increased considerably in the period up to around 1940 (with the Gini coefficient rising from ca. 0.35 to as high as 0.65 in one estimate). Moriguchi and Saez's own analysis using tax statistics and focusing on income concentration suggests that the income share of the top 1% stood at ca. 20% in 1886, the start of Japan's industrial revolution, but then dropped to 12% over the following ten years, before rapidly increasing again to around 18–20% by ca. 1901 and remaining at that level until around 1940 (Moriguchi and Saez, 2008: figure 6). They argue that the high degree of income concentration during this period was due to the concentra-

tion of land ownership, the concentration of business ownership, high compensation of the top management of corporations, and a legal system that was favorable to the affluent class.

However, income inequality declined markedly as a result of World War II. The income share of the top 1% in Moriguchi and Saez's analysis dropped precipitously to around 7% in 1945 (and subsequently oscillated in a relatively narrow range of 7–9% up until 2005, the last year of their analysis). Similarly, studies for the post-war period using the Gini coefficient for income inequality (also summarized in Moriguchi and Saez, 2008: figure 2) show that this starts at much lower levels than those seen around 1940. Minami (2008), for example, cites a Gini coefficient for non-primary industry of 0.335 for 1956 compared with a value of 0.666 for 1936–1939. Moriguchi and Saez (2008) ascribe this rapid decline in income concentration and inequality during WWII to government regulation, inflation, and war destruction.

Turning to the post-war period, the general pattern is one of declining income inequality during Japan's high-speed growth era during the 1950s and 1960s, more or less stagnating inequality during the period of more moderate growth during the 1970s, and (rapidly) increasing inequality from the 1980s onward. Looking at developments over the decades in greater detail, Economic Planning Agency (1957) suggests that wage inequality during the early 1950s was largely the result of Japan's so-called "dual economic structure" reflecting high wages in large companies and low wages in small companies. However, as Japan entered high-speed growth from the mid-1950s onward, labor market conditions tightened rapidly, the labor surplus turned into a labor shortage around 1960, and from the mid-1960s onward wage differences between large and small companies, as well as between workers of different age groups, started to decline (Ono, 1973). Following the end of high-speed growth in the early 1970s, labor market conditions changed again, the pace of decline in income and wage differences overall slowed, and income and wage differences between men and women, between different age groups, between firms of different size, and between managerial staff on the one hand and production and administrative staff on the other started to increase (Ishizaki, 1983).

From the 1980s onward, inequality started to rapidly increase

again (Minami, 2007), and a number of scholars have argued that to a large extent this reflects the onset of population aging in Japan. Ohtake (2000), for example, argues that if wage differences increase with age, then an aging of the workforce will result in greater inequality overall. He further points out that changes in household structures during this time, such as the increase in single-person households and in high-income married couples, also had a substantial impact. Shinozaki (2001), on the other hand, suggests that an increase in wage differentials due to the aging of the workforce at least among men can be observed only in the 1980s. In contrast, for the 1990s, he finds no increase in wage differentials due to aging and that because wage differentials both within and between age groups did not increase, there was no substantial change in wage differences.

While Ohtake (2000) and Shinozaki (2001) hypothesized that the main reason for the increase in wage differences was the aging of the workforce, Kambayashi, Kawaguchi, and Yokoyama (2008) focused on factors other than age. Empirically examining wage differences between 1989 and 2003, they found that these did not change very much during the observation period, but this reflects two countervailing trends: on the one hand, wage differences between workers with different characteristics (especially differences in educational attainment and tenure) tended to decrease; on the other, however, wage differences among workers with the same characteristics tended to increase. Further, Kawaguchi and Mori (2012) found that the results obtained by Shinozaki (2001) and Kambayashi, Kawaguchi, and Yokoyama (2008) remain unchanged even when including male non-regular workers in the analysis. Moreover, focusing in particular on wage differences between workers with different levels of educational attainment, they showed that the reason that wage differences by educational attainment remained unchanged is that the supply of university educated workers has kept pace with the increase in demand for such workers springing from skill-intensive technological progress and globalization.

In sum, the level of personal income inequality in Japan has fluctuated considerably through the course of the country's economic development over the past 130 years or so. Personal income inequality was particularly pronounced during the pre-war period, but was reduced markedly by WWII and further declined during the high-

speed growth era before increasing again from the 1980s onward. Given the long time span considered, the reasons both for inequality and changes therein have varied considerably over time.

Turning from personal income inequality to regional growth and inequality, research especially on the pre-war period is thin on the ground. To a large extent, this is due to the lack of data (which the present study seeks to address), and what data and estimates of regional income do exist appear to be seriously flawed. Furthermore, regional inequality was not the main focus of the studies that have attempted to estimate regional income for the pre-war period, namely Kokumin Keizai Kenkyu Kyokai [Society for the Study of the National Economy] (1956) and Matsumoto (2004).[9] Nevertheless, using these regional income estimates to calculate the coefficient of variation as a measure of regional income inequality suggests that regional inequality during the pre-war period—just like personal income inequality—rose rapidly during the pre-war period and was much higher than during the post-war period (see Chapter 2, in particular Figure 2.1, for details).

Looking at the post-war period, Japan has featured prominently in the debate on regional growth and convergence initiated by Robert Barro and Xavier Sala-i-Martin (e.g., Barro and Sala-i-Martin, 1992b, 2004). Using data from 1930–1987, they find evidence of both σ- and β-convergence during this period. Specifically, with regard to σ-convergence, they find that the cross-prefectural dispersion in per capita income increased during the period 1930–1940, but then decreased dramatically until hitting a minimum in 1978, after which it increased slightly. Similarly, with regard to β-convergence, they find that such convergence took place, i.e., poorer prefectures were growing faster than richer ones, during the observation period as a whole as well as during the 1930–1955 and 1955–1987 subperiods. Further, introducing regional dummies, they find that there is convergence both across as well as within broader regions. An important point to note with regard to their results for the earlier period and their whole-period estimates is that their data for 1930 are based on the prefectural

[9] The shortcomings of these estimates, and therefore their lack of reliability, are discussed in Yuan et al. (2009) in Japanese and, in a slightly amended version, in Bassino et al. (2010) in English.

income estimates by the Kokumin Keizai Kenkyu Kyokai [Society for the Study of the National Economy] (1956) (see Barro and Sala-i-Martin, 1992b, footnote 6), which greatly exaggerate the degree of inequality (see Appendix 2, Section A2.8).

A key issue that Barro and Sala-i-Martin address is the role of net migration across prefectures as a source of convergence. Finding that migration is strongly positively associated with initial income, they include migration in their convergence equation, but come to the conclusion that it does not appear to have been important in explaining β-convergence in Japan. Picking up on this result, which he calls the "migration puzzle," Shioji (2001) argues that the reason may be that the expected convergence effect of migration was offset by the impact of migration on prefectures' educational attainment and demographic structure. His empirical analysis shows that migration indeed appears to have affected regional human capital such that receiving regions gained in human capital per capita. However, he further finds that such "brain drain" effects are insufficient to offset the expected contribution of migration to β-convergence.

The study on regional income inequality during the post-war period most closely related to our interest is the one by Kataoka and Akita (2003). Using the weighted coefficient of variation and the Theil index, i.e., focusing on σ- rather than β-convergence, they examine developments in regional inequality and explore the factors determining inequality using various decomposition techniques. Interestingly, the trend over time in regional inequality they find closely mirrors that in personal inequality. That is, the weighted coefficient of variation first increased until reaching a peak in 1958, before declining steadily until reaching a nadir in 1979. It then rose again to reach another peak in 1990 that was more or less as high as that in 1958, before subsequently declining again. Further, they find that regional inequality in per capita GDP to a considerable extent is determined by regional inequality in labor productivity, while differences in labor participation rates did not play a significant role.

In sum, existing studies on trends in inequality and convergence in Japan during the period we focus on suggest that the pre-WW II period was characterized by both substantial personal and regional income inequality. In contrast, inequality during the post-war period has been considerably lower, and personal and regional income

inequality display very similar trends over time. In particular, both individual and regional inequality appear to have unambiguously declined during the period that roughly corresponds to Japan's high-speed growth era (ca. 1955–1973). However, the 1980s then appear to have been a period of growing inequality in terms of both personal and regional per capita incomes. In particular, regional income inequality appears to have fluctuated markedly since that decade, suggesting that regional convergence is not inevitable and that, potentially, Barro and Sala-i-Martin for their analysis of β-convergence happen to have picked a period when regions were indeed converging thanks to relatively rapid overall growth.

1.8 Data limitations in preceding studies on regional inequality in Japan and current availability of data and estimates

A number of studies have sought to examine regional development patterns in Japan. But the literature to date remains rather limited and patchy, largely due to the lack of relevant data. This is particularly the case for the pre-war period, for which the only preceding estimates of per capita prefectural output are those by the Kokumin Keizai Kenkyu Kyokai [Society for the Study of the National Economy] published in 1956 and by Matsumoto (2004) for a small number of benchmark years from 1905 to 1940. However, in addition to their limited range, these estimates suffer from a variety of shortcomings, and depending on whether prefectural output is estimated from the income or the production side they produce greatly different results in terms of both the level of and trend in regional inequality. This means that in fact little is known about regional inequality in Japan during the pre-war period, and studies on the determinants of such inequality and divergence or convergence therein are lacking entirely.

The situation is considerably better for the post-war period. Statistics on gross prefectural products, which we will refer to as GPP hereafter, on output and labor input by industry, etc., have been published since 1955, and numerous studies have been conducted using such data to examine trends in post-war regional growth and inequality and the factors determining these trends. Examples include the

studies by Barro and Sala-i-Martin (1992b) and Shioji (2001) focusing on regional convergence in a neoclassical growth framework and Fukao and Yue (2000) and Akita and Kataoka (2003) using a decomposition approach. Yet, although these studies have made important contributions to our understanding of regional income patterns in Japan, there remains considerable room for improvement. For instance, Barro and Sala-i-Martin (1992b) and Shioji (2001) treat convergence as a "black box" without elucidating the mechanisms underlying it by, for example, decomposing it into convergence in factor inputs per capita and convergence in TFP. On the other hand, although Fukao and Yue (2000) do provide such a decomposition, their study is based on a one sector model that does not take account of differences in industrial structure as well as differences in factor inputs and TFP across regions. Meanwhile, Akita and Kataoka (2003) mainly focus on the contribution of inequality within and between crude sectors (primary, secondary, tertiary) to overall regional inequality without considering the role of factor inputs or TFP.

Against this background, the aim of the present study is to present a comprehensive examination of patterns of regional inequality in Japan and their determinants from a long-term perspective covering the period from shortly after the Meiji Restoration to the most recent year for which comprehensive data are available, that is, the roughly 130 years from 1874 to 2008. Specifically, using new, original estimates of gross prefectural products (GPP), we trace the trend in the coefficient of variation in per capita GPP over the entire observation period and then investigate the various factors driving developments therein. The level of detail at which we are able do so is largely determined by the availability of data, which, for obvious reasons, is more limited the further we go back into the past. Concretely, our data can be divided into three types: (1) data constructed for certain benchmark years from 1874 to 1940 and then available annually from 1955, such as GPP; (2) additional data available from 1955 onward (physical capital stock for every year and human capital stock for benchmark years); and (3) further additional data available from 1970 onward.

Much of the research effort underlying this study has gone into the estimation of new, original prefecture-level data for the period 1874-1940, which we will refer to as the pre-war period. Compared with other Asian countries, Japan from the Meiji period onward is a

treasure house of statistics, and a large amount of prefectural data are available, such as the *Fuken Tokei Sho* [*Prefectural Statistics*] published annually by each prefecture as well as aggregate tables by prefecture of various statistical surveys, such as the *Kojo Tokei Hyo* [*Factory Statistics*]. Making use of these sources, we compiled estimates of GPP from the production and income sides.[10] An advantage of estimating GPP from the production side is that it becomes possible to analyze changes in prefectures' industrial structure. Consequently, we estimated nominal and real gross value added, gross output, and intermediate input by prefecture with regard to 16 industries covering the whole economy. In addition, we estimated the number of occupied persons by eight slightly more aggregated industries plus the number of non-occupied persons, as well as rates of interprefectural migration. A detailed documentation of the sources and estimation methodology is provided in Appendix 2. The statistics thus compiled for the pre-war period allow us to examine in detail the role of industrial structure and migration and their contribution to inequality in convergence. Unfortunately, sufficient data for the construction of prefectural capital stock series are unavailable for the pre-war period. This, however, changes for the post-war period, so that it become possible to examine the role of regional factor inputs in convergence. Specifically, for the period from 1955 onward, we used data from the *Kenmin Keizai Keisan Nenpo* [*Annual Report on Prefectural Accounts*] (various years) published by the Economic and Social Research Institute, Cabinet Office (formerly, Economic Planning Agency, EPA).

The data we have at our disposal become more and more detailed the closer we get to the present, and consequently, the analyses we

[10] National and regional accounts can be estimated from three sides, that is, the production, income, and expenditure sides. In the estimation of historical national accounts (e.g., Mizoguchi, 2008), (regional) GDP is often estimated from the production and income side, gross domestic expenditure from the expenditure side, and the validity of the estimation is confirmed by comparing the two estimates. However, because sufficient statistics with regard to trade in goods and services among regions within one country are not available, retroactive long-term estimation of gross prefectural product using the expenditure approach is extremely difficult. For this reason, we decided to estimate GPP only from the production and income sides.

conduct also become more detailed for the more recent periods. For benchmark years from 1955 onward, we estimated capital stock and human capital at the macro level for each prefecture. A detailed documentation of the sources and estimation methodology is provided in Appendix 3. These data make it possible to estimate total factor productivity (TFP) at the macro level and examine its contribution to regional convergence. As discussed above, TFP, which measures the efficiency with which factors of production are used and represents technology in the broadest sense, is a potentially important determinant of regional inequality, given that the spatial pattern of technology adoption is likely to be uneven and differ over time.[11]

For benchmark years from 1970 onward, we use the Regional-Level Japan Industrial Productivity (R-JIP) Database, which contains data on capital stock and human capital by industry and by prefecture.[12] A detailed documentation of the sources and estimation methodology of the R-JIP database is provided in Appendix 4. These data make it possible to estimate how physical and human capital deepening and TFP growth in each industry contributed to regional convergence. Studies examining factor inputs and TFP by prefecture and industry include those by Higuchi et al. (2003) and Nakajima, Nakahigashi, and Hino (2002); however, their analyses suffer from various problems. For example, they treat manufacturing as one industry and for capital stock in non-manufacturing industries use data by ESRI (Economic and Social Research Institute, Cabinet Office), the estimation of which is based on unusually strong assumptions.[13]

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[11] For instance, until the 1970s, Japan was an industrial follower and imported new technologies through licensing and reverse engineering (Goto, 1993), but from the 1970s onward started to increasingly conduct its own research and development (R&D). Most of these activities were conducted by large firms located in urban areas, but in the 1970s and 1980s such firms with leading-edge technologies increasingly relocated production to rural areas, while in the last two decades or so, production has increasingly been shifted abroad. This pattern of technological upgrading and relocation of production activities is bound to have affected regional TFP patterns.

[12] The R-JIP database is estimated as a joint project of the Research Institute of Economy, Trade and Industry (RIETI) and Hitotsubashi University and some of authors of this volume (Tokui, Fukao, and Makino) are core members of this project.

1.9 Outline of the remainder of the book

This book falls into two major parts with a total of seven chapters (including the present chapter) and four appendixes. The first part, consisting of Chapters 2 to 4, covers both the pre-war and the post-war period, while the second part, consisting of Chapters 5 and 6, provides a more detailed analysis on the post-war period. Focusing on both the pre-war and the post-war period, the following three chapters first examine inequality and convergence (Chapter 2), then analyze how changes in industrial structure contributed to inequality and convergence (Chapter 3), and finally analyze the link between growth, migration, and convergence (Chapter 4). The next two chapters then deal first with regional factor inputs and convergence in the period 1955–2008 (Chapter 5) and with factor inputs and TFP at the industry level as explanatory factors of regional convergence in the period 1970–2008 (Chapter 6). Chapter 7 summarizes the main findings and concludes. At the end of the volume, Appendix 1 presents new estimates of agricultural production, proto-industrialization, and urbanization for the period 1600–1874. This is followed by Appendix 2, which provides a detailed description of the procedures used for constructing the pre-WWII prefectural data, while Appendixes 3 and 4 present details of the construction of prefectural data for the post-war period.

[13] Specifically, ESRI estimates investment flows in a certain industry in each prefecture by distributing new investment in "[gross] capital stock of private enterprises" at the national level in that industry based on the proportion of prefectural value added of that industry in the *Prefectural Accounts*, and estimates capital stock using the benchmark year method. This approach imposes the strong assumption that the investment-value added ratio is the same in all prefectures.(The private investment expenditure series of the *Prefectural Accounts* are also estimated in more or less the same way.)

Chapter 2

Regional Inequality and Convergence in 1874–2008

2.1 Introduction

This chapter provides an overview of regional inequality and convergence during the period 1874–2008, where for the pre-war period we use the new estimates of per capita gross prefectural product (GPP) for our six benchmark years (1874, 1890, 1909, 1925, 1935, and 1940),[1] while for the post-war period we rely on existing estimates of prefectural per capita income for 1950 (KKKK, 1956)[2] and official figures of per capita GPP and prefectural income for 1950 and 1955–2008.

The new pre-war figures allow us to measure levels of and trends in regional inequality with greater accuracy than has been possible with data available so far. Our findings indicate that Japan, like many other countries over the course of their economic development, first

[1] The sources and procedures used for the estimation of GPP for 1874, 1890, 1909, 1925, 1935 and 1940 and other data are presented in Appendix 2. For benchmark years others than 1874, our figures at the national level do not differ from those presented by Ohkawa, Takamatsu, Yamamoto (1974) and Ohkawa and Shinohara (1979). Our contribution is that we constructed a regional breakdown of national GDP.

[2] KKKK stands for Kokumin Keizai Kenkyu Kyokai [Society for the Study of the National Economy]. KKKK also provides estimates for 1930, 1935, and 1940.

experienced an increase in regional inequality and then a decrease. Specifically, we find that the rise in regional equality took place mostly during the Meiji period (our benchmark years are 1874, 1890, and 1909), inequality reached a plateau between 1909 and 1950, with some fluctuations, and then declined almost continuously until the 1980s. The historical peak of regional inequality, in 1935, was at a level not much higher than in 1909 or 1950. We also find that the measure of regional inequality is higher when using coefficients of variation weighted by population than when using unweighted coefficients, for both the pre-war and the post-war period.

The aim of this chapter is to examine these long-term trends in regional inequality in per capita GPP in detail. To do so, it assesses the relationship between economic and biological well-being using prefectural averages of height, provides an assessment of regional living standards and rank stability, and presents an international comparison of regional inequality taking into account differences in levels of per capita GDP.

2.2 Long-term trends in regional inequality

In this section, we examine developments in regional inequality over time. To do so, we calculate the population-adjusted coefficient of variation of per capita GPP or income to determine whether regional inequality in Japan followed an inverted U curve. This can then be compared with the evolution of prefectural average height, which is one of the most standard indicators of biological well-being.[3] In addition, we then examine the extent to which prefectures' relative position in terms of per capita GPP has changed over time. This allows us to uncover possible long-term effects of initial conditions and/or path dependence, and we examine this issue by calculating the rank order stability of per capita GPP. We also investigate the relationship between economic and biological indicators of well-being using information on the average height of conscripts born in the Meiji period, and of students born in the inter-war or the immediate post-war

[3] The other most commonly used indicator is infant mortality; however, data on infant mortality in Japan are not entirely reliable for the pre-war period due to probable underreporting.

period.

One of the most commonly used measures of regional inequality is the coefficient of variation (CV, i.e., the standard deviation divided by the average). For instance, Barro and Sala-i-Martin (1992b) in their study on regional inequality in Japan covering the period 1930-1987 use, in log form, an unweighted coefficient to assess changes in the dispersion of per capita GDP. A major shortcoming of this approach is that, within any given country, the different regional units do not have the same population size and, furthermore, the share of a given region in the total national population can change over time due to differences across regions in natural population growth and/or due to domestic and international migration. A more appropriate approach for assessing changes in the per capita income distribution across regions therefore is to use the population-adjusted CV of regional inequality (Williamson, 1965). The formula is:

$$CV_r = \frac{\sqrt{\sum_r \frac{N_r(y_r - y)^2}{N}}}{y}, \qquad (2.1)$$

where y_r stands for the per capita income or GPP of region r, y is national per capita income or GDP, N_r is the population of region r, and N is the national population.

An additional adjustment is required in order to take into account regional price differences and generate per capita GPP at purchasing power parity. Large regional differences can be observed for a number of important items, in particular rice and other staples, in the 1870s and 1880s as well as during the second half of the 1940s. The price of staples was usually lower in rural prefectures that had a large structural exportable surplus. In 1874, local prices were above the national average in most prefectures of western Japan and well below the national average in most prefectures of eastern Japan. However, prices converged rapidly in the 1880s and 1890s.[4] 1874 and to a lesser extent 1890 are therefore the only pre-war benchmark years for which the calculation of GPP at national prices results in a sizable adjustment.

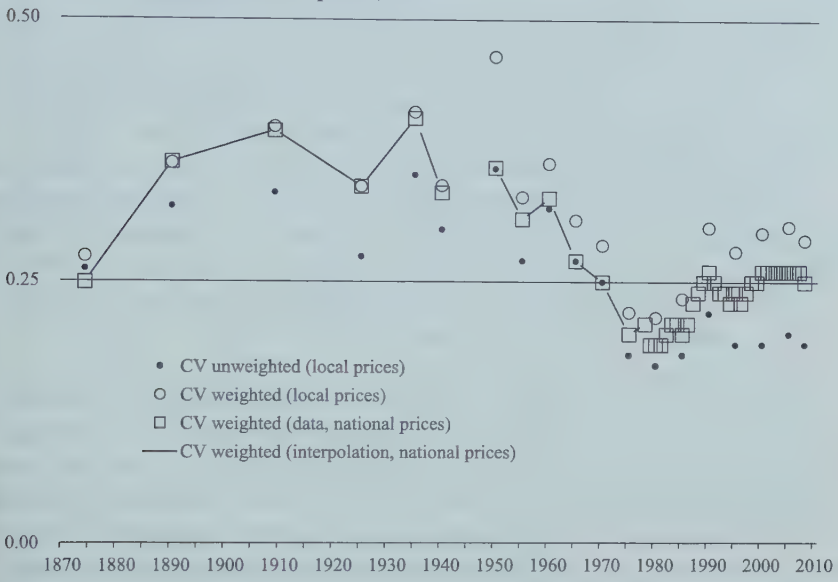
[4] In the case of service prices, price gaps must have continued to exist. Due to the lack of data for service prices for the period 1874-1940, we did not take account of these differences in the pre-war period.

The economic collapse of 1944–1945 resulted in a disintegration of regional markets and therefore regional price divergence. The exact conditions are difficult to assess for the immediate post-war years up to the end of the 1940s due to the development of black markets in parallel with the rationing of essential food and non-food consumption items and strict state control of foreign and domestic trade for most other goods. Information available for 1950 indicates that local prices were still above the national average in the most urbanized prefectures as a consequence of food shortages in these areas, and well below the national average in prefectures with a structural surplus of staples. Regional prices converged rapidly in the 1950s, but the overall price level remained higher in urban areas due to higher labor and logistics costs (in particular storage costs).[5]

Figure 2.1 presents the weighted CV of per capita GPP at local and national prices for Japan thus obtained for the period 1874–2008, along with the unweighted CV at local prices. The three series show a rather neat inverted U curve of regional inequality, at least up to the 1970s. That is, regional inequality increased during the early phase of Japan's modern economic development during the late 19th and early 20th centuries, peaked in the first half of the 20th century, and then generally declined.[6] Moreover, the shape of the curve is very similar regardless of whether we look at the population-weighted or the unweighted CV. The gap between the unweighted and weighted series increases in the late 19th century as a consequence of the combined effects of price convergence and the rise in the total population share of prefectures with the highest per capita GPP.[7] In each year

[5] For the estimation of purchasing power parity (PPP) adjusted GPP we would need price gaps of all the outputs and inputs. For the 1955–2008 period we take a short-cut approach by using CPI price gaps as a proxy for price differences of net output. Prefectural GPP series were adjusted for regional price differences using the *Regional Difference Index of Consumer Prices* (General Index) computed by the Japanese authorities using unit prices collected in prefectural capital cities. Due to the lack of GPP data for 1950, available estimates of per capita income, adjusted for regional price differences, are used as proxies. Information related to the data sources and estimation procedures employed to calculate indices of regional price differences and to generate proxies of prefectural per capita income at purchasing power parity in 1950 are described in Appendix 2 (Section A2.7).

Figure 2.1 Long-term trends in the coefficient of variation of per capita GPP (in local and national prices)


0.50
0.25
0.00
• CV unweighted (local prices)
○ CV weighted (local prices)
□ CV weighted (data, national prices)
—— CV weighted (interpolation, national prices)
1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010

(in cross-section data), weighting per capita GPP in local prices by the prefectural population results in a higher CV because the richer prefectures had a large population, particularly Tokyo and Osaka. Using national prices lowers the CV, because the poorest prefectures tend to have lower prices; their GPP in national prices therefore tends to become higher, relative to the national average, than GPP in local prices. These two effects thus tend to cancel each other out in a cross-section comparison.[8]

Although overall the CV forms a clear inverted U curve, some

[6] Results for the Tokugawa period presented in Appendix 1 (footnote 18) suggest that regional inequality in Japan declined from 1720 to 1750 and then remained more or less unchanged for the next 100 years before increasing between 1850 and 1874. Although these results are preliminary and for 14 regions of Japan (rather than the 47 prefectures considered in the remainder of the book), they suggest that the increase in regional inequality commenced sometime before our first benchmark year (1874).

[7] The role of migration flows in this process is analyzed in Chapter 4.

fluctuations can be observed, particularly between 1909 and 1950. We find that the CV declined in 1909–1925, 1935–1940, and from the mid-1950s to the 1970s, which were all periods of rapid economic growth associated with the steady development of manufacturing activities.[9] Our interpretation, as will be discussed further in the next chapters, is that during these three subperiods technology diffusion contributed to the development of manufacturing activities in peripheral Japanese regions that had a comparative advantage in labor-intensive activities due to their relatively low wage rates. This helped to reduce the gap between poorer rural prefectures and richer prefectures in which manufacturing and other activities, particularly transportation and utilities, had started to develop earlier, in the late 19th century, with the help of western technology.

On the other hand, the coefficient of variation increased from 1925 to 1935 in the context of economic stagnation and a relative decline in the price of agricultural products. It also increased again between 1940 and 1950 as a consequence of the collapse of the economy in 1945 and the loss of the colonial empire, which particularly affected the prefectures of western Japan. This was amplified by migration from urban prefectures, which had a comparatively high GPP per capita, to poorer rural prefectures during the period 1944–45 due to the US bombing of residential areas and difficulties in food provisioning in the largest cities. The coefficient also increased in the 1980s against the backdrop of

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[8] The effect resulting from the use of national prices is, however, limited in 1874 and 1890, because price levels were higher in rural prefectures of western Japan than in those of eastern Japan (local price levels were not correlated with PPP-adjusted per capita GPP). The effect is also small for 1909, 1925, 1935, and 1940 due to the fact that regional differences in unit prices declined in the 1890s and remained at a low level until the early 1940s. A possible additional explanation for the small gap observed between per capita GPP in local and national prices in the period 1874–1940 is the lack of adjustment for service prices (as already mentioned in footnote 4).

[9] Annual data are available only from 1955 onward, while for the period before then, we only have data for benchmark years. This means that we cannot determine the exact timing of the turning point and of the temporary decline in the CV in 1909–1925 and 1935–1940. The construction of yearly series of prefectural GPP would allow a more precise identification of the timing of peaks and troughs.

Table 2.1 Coefficient of variation and ratio of per capita GPP of wealthiest to poorest prefectures

	1874	1890	1909	1925	1935	1940	1955	1970	1990	2008
Population-weighted coefficient of variation at national prices										
47 prefectures	0.25	0.36	0.39	0.34	0.41	0.34	0.31	0.25	0.26	0.25
Ratio of per capita GPP of top 20% and 50% to bottom 20% and 50% of prefectures										
20%	1.83	2.12	2.30	2.25	2.92	2.37	2.28	2.17	2.03	1.84
50%	1.44	1.53	1.62	1.60	1.90	1.76	1.72	1.62	1.50	1.45

Note: The calculations for 1955 and 1970 are for 46 prefectures only, since data for Okinawa, which was under US administration at the time, are not available.

deindustrialization. The rise was further amplified in the second half of the 1980s by the economic bubble that inflated not only land values but also revenues in construction and service activities in the major urban areas, first in Tokyo and surrounding prefectures, then in Osaka, and finally in Nagoya and other large cities. However, by the mid-1990s, the coefficient had returned to close to the pre-bubble level, but resumed an upward trend as a consequence of the rising share of the population living in the most urbanized areas.

To supplement the analysis of trends in regional inequality using the coefficient of variation of per capita GPP, we also examine the trend in the ratio of the per capita GPP of the top 20% and 50% of prefectures in term of cumulative population relative to the per capita GPP of the bottom 20% and 50% of prefectures (Table 2.1). Again, the results show that inequality rose between 1874 and 1909, declined slightly between 1909 and 1925, then rose again and reached an all-time peak in 1935, and declined steadily until the 1970s, before fluctuating at a low level since then.

The analysis of regional inequality in terms of per capita GPP showed that this followed an inverted U curve. This raises the question whether a similar trend can be observed for other indicators of well-being. Potential indicators include economic indicators such as prefecture-level wage rates adjusted for regional price differences and biological indicators such as the average height of a given cohort. We use both indicators.

Regarding economic indicators, probably the most reliable data for

the pre-war period are annual series of real wages by prefecture calculated by Saito (2005).[10] These series show that regional wages were converging from the 1900s to the 1930s, which, as seen in Figure 2.1, was a period when the CV of per capita GPP was relatively stable. However, a sizable gap between rural and urban wages persisted throughout the period.[11] The implication is that the increase in regional inequality in terms of per capita GPP between 1874 and 1909 was due to the expansion of the manufacturing sector, which brought about a rise in both capital income and wages paid to factory workers, whose labor productivity was presumably higher than that of workers in the primary sector.[12] This is consistent with a higher level of capital accumulation per resident in the most urbanized prefectures that experienced industrialization in the late 19th century and accounted for the major share of capital-intensive manufacturing and service activities. These differences are discussed further in Chapter 3.

Next, as an indicator of biological well-being, we use individuals' body height, which reflects the cumulative effects of nutritional status, exposure to diseases, and other environmental conditions (Eveleth and Tanner, 1991; Steckel, 1995). Although individual height is strongly influenced by genetic factors, these are unlikely to play any role when the measure is the average for a large population, particularly when regional differences in the genetic pool are small, which is the case within Japan (Cavalli-Sforza, Menozzi, and Piazza, 1994: 230–231). For data on body height in pre-war Japan, we can rely on two types of sources: first, conscription reports for cohorts born between 1873 and 1917 and measured at age 20 (around 98% of the cohort for each year); and second, Ministry of Education surveys of the average height of male and female students available for 1928–1938, 1948–1949, and since 1953. Average height was recorded for the different cohorts from age 8 to 20. However, due to problems of coverage, the measure of height does not reflect the biological standard of living of individuals

[10] His yearly series of prefectural real wages of skilled and unskilled workers were constructed by adjusting nominal wages by rice prices.

[11] The rural-urban wage gap can be measured by comparing daily wage rates paid to agricultural workers and metal workers. The gap was on a rising trend from 1927 (that is, before the effect of the world depression on agricultural prices) until around 1933, but declined in the late 1930s.

aged between 14 and 18 before the cohorts born in the 1950s.[13] Data for cohorts born in the three benchmark years 1925, 1940, and 1950 are available only for measurement at age nine (i.e., in 1934, 1949, and 1959, respectively) due to the interruption of the survey (or the loss of records) during the war, and for several years coverage is limited to only eight prefectures.

Before considering changes in regional inequality in terms of average height, we should examine the relationship between prefecture-level average height and per capita GPP (up to 1940).[14] Table 2.2 presents the estimation results of OLS regressions in semi-log

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[12] The period was also one of regional price convergence, particularly with regard to staples that were traded the most extensively across prefectures, such as rice and soybeans. There may be a causal relationship between price convergence and the divergence of per capita GPP in that the prefectures of western Japan, which initially had the highest price levels, benefited disproportionately from the integration of some of the prefectures of eastern Japan, which initially had the lowest price levels, into the national market in the late 19th century. It should also be noted that the degree of market integration had been particularly high since the 18th century in the central and western parts of Honshu (Miyamoto 1981, 1985), which probably had a higher per capita GPP than the eastern part of Japan. The process of regional price convergence can be interpreted as resulting from the combined effects of declining transportation and transaction costs. However, improvements in transportation technology played a more limited role for commodities with a high value per unit of weight, such as silk. For instance, the price difference in the price of cocoons in Suwa and Maebashi, two production areas of inland eastern Japan, and in Yokohama, the major Japanese exporting port for silk products, was around 50% in the years following the opening to international trade, but the gap, although fluctuating widely in terms of yearly averages, was on a rapidly declining trend in the 1860s (Miyamoto, Sakudo, and Yasuba, 1965: 554). This implies that regional price convergence after 1874 was mostly driven by changes in the unit prices of bulky goods. A similar regional convergence also occurred for interest rates measured at the prefecture level between 1885 and 1924 (Mitchener and Ohnuki, 2009).

[13] Above age 14, the school enrolment rate remained very low until the 1950s, so that the data are not representative for the entire cohorts and the evolution of average height can therefore only be regarded as indicative of changes in the socioeconomic conditions of individuals from top-income households in the prewar period.

Figure 2.2 Map of Japanese prefectures and regions

Note: The figure shows the current administrative division of Japan into 47 prefectures. A description of how we adjusted information for the 71 prefectures in 1874 to make it consistent with the current 47 prefectures is provided in Appendix 2. The regions indicated in the map are not administrative units but prefectures that are conventionally grouped together as regions.

Table 2.2 Estimation results for the relation between prefectural average height and GPP

	(1) Conscripts aged 20	(2) Male students aged 9	(3) Female students aged 9
log(GPP per capita)	10.46 (2.90)***	16.95 (5.99)***	15.11 (5.99)***
D1874	−31.36 (−16.15)***		
D1890	−15.39 (−8.22)***		
D1940		−76.15 (−45.52)***	−8.55 (−4.28)***
D1950		−88.71 (−44.50)***	84.37 (51.02)***
Intercept	1523 (74.53)***	1138 (54.16)***	1063 (51.22)***
Adj. R^2	0.74	0.96	0.96
Observations	140	139	139

Notes: Equation (1) is based on average height for cohorts born in 1874, 1890, 1909 and PPP-adjusted GPP in these years, while equations (2) and (3) are based on average height for cohorts born in 1925, 1940, and 1950 and PPP-adjusted GPP in these years. For conscripts, 1909 is the omitted year dummy; moreover, height data for Okinawa are missing for 1874 (year of measurement). For students, 1925 is the omitted year dummy; height data for Okinawa are missing for 1949 and 1959. t-values in parentheses. *** denotes significance at the 1% level.

Sources: Conscription reports for individuals measured at age 20 in 1894, 1910, and 1929 (born in 1874, 1890, and 1909). See Bassino (2006a) for a detailed presentation of data sources. Surveys of the Ministry of Education for the average height at age 9 of students born in 1925, 1940, and 1950.

specification, with height (measured in millimeters) as the dependent variable and GPP per capita at purchasing power parity (PPP) as the explanatory variable, along with time dummies for the different cohorts.(Similar results are obtained when using a log-log specification or fixed effects regressions). We find a positive and significant relationship between per capita GPP and body height for all observa-

[14] Japanese average height in the late 19th and early 20th century was extremely low by international standards. For instance, in terms of the significant and positive relationship between per capita GDP and average height measured by Steckel (1995) using country level data, Japan is clearly an outlier: actual height appears to have been much lower than predicted by Japan's per capita GDP level in the late 19th and early 20th century. However, since we are investigating the relationship between average height and income at the prefectural level (and immigration, which could skew the results, was negligible), the low average height of the Japanese is irrelevant.

tion years. For the period from 1950 onward, a similar investigation using per capita income and the body height of males and females aged 17 by Bassino and Kato (2010) shows that such a relationship can also be observed for the second half of the 20th century, although the relationship has become weaker in recent decades.

Having found that regional differences in average height are closely linked to differences in per capita GPP, we can now examine whether long-term changes in the CV of prefecture averages of body height display a similar trend as changes in the CV of per capita GPP. Because in a country such as Japan with relatively homogenous socio-economic and environmental conditions the regional variation in average height is limited to a narrow range, the value of the coefficient is obviously very small. In the Japanese case, the highest and lowest prefectural averages for conscripts born in 1890 were 1593 and 1545mm (in Shiga and Okinawa prefectures, respectively). Looking at the CV of body height (not shown), we find that this is quite stable and shows only minor changes. Specifically, we observe a mild downward trend between 1873 and 1895, followed by an equally mild upward trend between 1895 and 1917 (years of birth of conscripts).[15] This contrasts with the trend of the CV for per capita GPP shown in Figure 2.1, which increases up until 1909 and then fluctuates. A possible explanation of the contrast between the upward trend in regional inequality in per capita GPP until 1909 and the downward trend in regional inequality in average height is the positive effect of public policies on the biological standard of living. New public goods were provided by the Meiji government throughout the country, including in rural areas, as part of public health policies. However, another likely reason for the height convergence is rising mortality due to communicable diseases such as tuberculosis up to the late 1910s, prevalence of which was proportionately higher in urban and industrialized areas (Hanashima and Tomobe, 2012).

Summing up, our analysis shows that regional inequality in per capita GPP measured using the population weighted CV followed an inverted U curve, with the CV increasing from 1874 to 1909, fluctuating at a relatively high level between 1909 and 1950, and then generally declining during the post-war period (albeit with a temporary

[15] Bassino (2006a: 79), figure 1 (the figure shows years of measurement).

increase in the 1980s). However, when using average height as an alternative indicator of well-being, regional inequality appears to have declined between 1874 and 1895, possibly as a results of public health measures by the Meiji government. In order to gain a better grasp of these different trends in income and height, in the following section we look at actual levels of these indicators for individual prefectures.

2.3 Evolution of living standards at the prefecture level

In this section, we look at absolute levels of prefectural income by relating per capita GPP to the subsistence level, which we proxy using the World Bank's $1 a day poverty threshold (i.e., $365 per year), and compare these figures with available prefecture-level information for other indicators of well-being. The aim is threefold: first, to assess how prefectural per capita income is related to other indicators of well-being in the initial period of Japanese economic development; second, to investigate to what extent prefectures with the lowest income experienced an improvement in absolute terms during the course of Japan's pre-war economic development; and third, to assess how these the poorest prefectures were affected by World War II and the economic dislocation of the immediate post-war period. Since Japan was already a middle-income country by the late 1950s, we focus on the period 1874-1950.

As is well-known, Japan embarked successfully on an industrialization process in the late 19th century that rapidly lifted living standards well above subsistence level as measured by national averages. On the basis of estimates in the Long-Term Economic Statistics (LTES) for Japan in constant Japanese prices (Ohkawa and Shinohara, 1979) and some additional sources, Maddison (2003) suggested that average per capita income in Japan (in 1990 international Geary-Khamis dollars) was only $756 in 1874, but then rose rapidly thereafter, reaching $1,012 in 1890, $1,304 in 1909, $1,885 in 1935, $2,120 in 1935, and $2,874 in 1940. Our own estimate of the national average for 1874 based on regional estimates is $862, that is, 14% higher but not vastly different.

Using the World Bank poverty threshold, the figures indicate that Japanese per capita GDP in 1874 was more than twice the subsistence level. However, in the case of relatively large and populous nations,

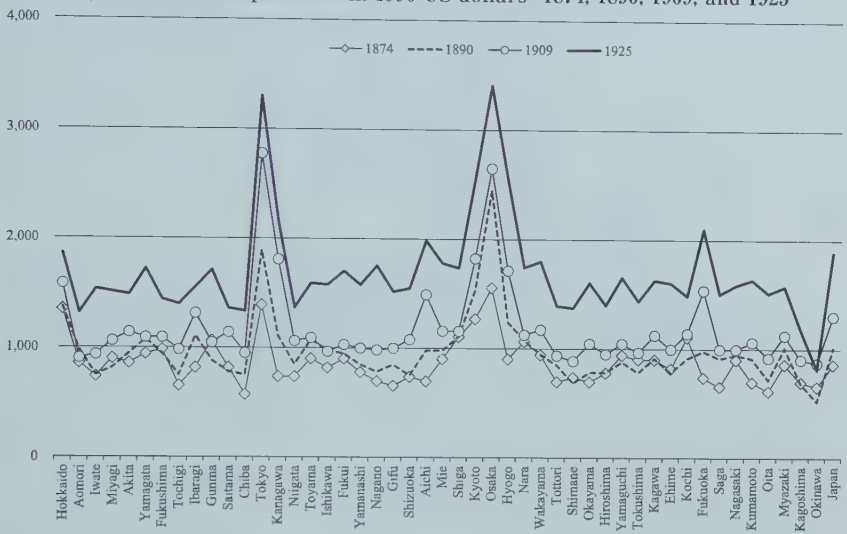
country-level averages potentially hide sizable differences in living standards, so that it is possible that pockets of poverty remained.

Japanese per capita income was still relatively low in the late 19th century when compared to the United States and most European countries. Our per capita figure for Japan in 1874 of $862 is about a third of the average level of the most affluent Western countries of comparable population (Britain, $3,386; Germany, $2,124; France, $2,157; United States, $2,527), where regional poverty pockets still existed. Moreover, Japanese per capita GDP was only slightly more than half of that of southern European countries that were also poor and latecomers in the industrialization process (Italy and Spain: $1,513 and $1,459), and for which the presence of large areas of very low living standards is well documented, and even lower than the poorest European countries for which reasonably dependable GDP estimates exist (Finland and Portugal, $1,204 and $966 respectively in 1874; Greece $880 in 1870).[16]

On the basis of country-level estimates of per capita GDP (Maddison, 2003), and relying on our estimates of prefecture-level per capita GDP at national prices, i.e., at purchasing power parity, we can generate figures in international 1990 US dollars. Following the World Bank, we consider $1 a day ($365 per year) as the subsistence level and $2 a day ($730) as a level sufficient to reduce the exposure to shocks (such as a rise in the price of staples). This second threshold can therefore be regarded as a level sufficient to allow lower income households to improve their nutritional pattern and to adopt strategies of investment in fixed assets and/or human capital. Since our per capita GPP estimates only capture prefectural averages, it is still possible

[16] According to the estimates constructed by Maddison (2003) for 1870 (his benchmark year for the second half of the 19th century), average per capita GDP in Japan was, at $737, higher than that in other Asian countries, in particular Indonesia ($654), Malaysia ($663), Thailand ($608), the Philippines ($624) and Vietnam ($505), and it was well above that in China and India ($530 and $534, respectively); the sole exception was Sri Lanka ($851) (http://www.ggdc.net/maddison/historical_statistics/horizontal-file_03-2007.xls). Since these GDP estimates are the subject of considerable debate and may need to be revised, it cannot be ruled out that the income gap vis-à-vis Japan was somewhat smaller than the figures here suggest.

Figure 2.3 Per capita GPP in 1990 US dollars: 1874, 1890, 1909, and 1925



Source: See text. GPP estimated in national prices.

that there was considerable personal income inequality within prefectures. However, available information suggests that at least in rural prefectures personal income inequality was relatively low, so that the prefectural average likely provides a good indication of the living standard of the large majority of individuals in that prefecture.[17]

The results for 1874, 1890, 1909, and 1925 are presented in Figure 2.3. In 1874 and 1890, per capita GPP was at least twice as high as the subsistence level (i.e., $730) in most prefectures but, as one would expect with the relatively low CV found in Section 2.2, not much above that level. In 1874, 13 prefectures (out of 47) had a per capita GPP of less than $730. The situation had significantly improved by 1890, with only four prefectures registering a per capita GPP below $730. How-

[17] For instance, Yazawa (2004: 54, table 1-3) provides information on the spatial distribution of the 5,000 top-income households by prefecture of residence in 1936, which shows that they were all located in the richest and most urbanized prefectures (2,009 households in Tokyo, 1,262 in Osaka, 502 in Hyogo, 323 in Kyoto, 314 in Aichi, 179 in Kanagawa, 78 in Hokkaido, 60 in Hiroshima, and 58 in Fukuoka).

ever, even the richest Japanese prefectures had a per capita GPP that was well below the average of the most advanced European countries and only on par with the national averages for Italy and Spain. Tokyo and Osaka, the two most affluent prefectures, registered respectively $1,392 and $1,556 in 1874 ($1,893 and $2,448 in 1890), while Kyoto's per capita GPP stood at $1,270 ($1,534 in 1890), and resource rich Hokkaido, which was still sparsely populated at that time, registered $1,351 ($1,371 in 1890).[18]

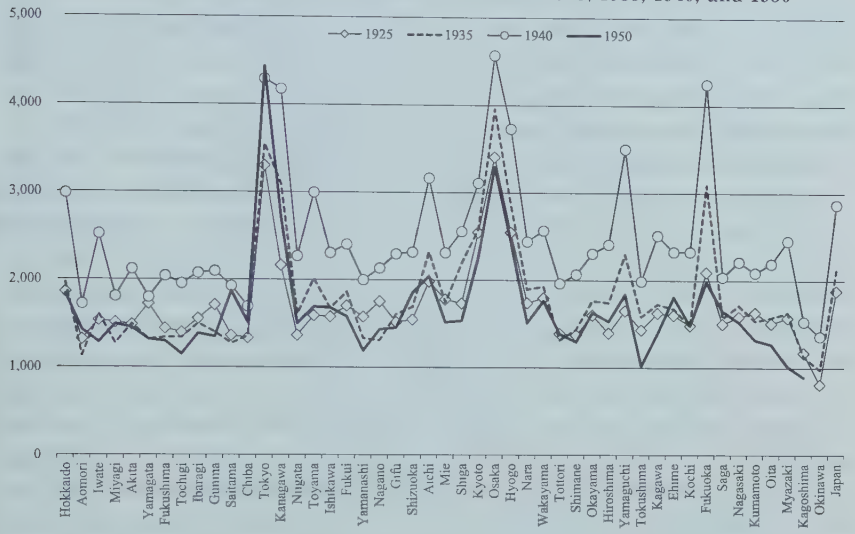
Both per capita GPP figures and prefecture-level height data indicate that rapid improvements in living standard occurred throughout the country around the turn of the 20th century, particularly in the poorest rural prefectures. By 1909, per capita GPP was above $730, more than twice the subsistence level, in all prefectures. The most decisive rise occurred between 1909 and 1925, particularly during World War I, a period that witnessed steady economic growth and industrialization. In most rural prefectures, per capita GPP in 1925 was around 50% higher than in 1909. By 1925, per capita GPP was above $1,095 (more than three times the subsistence level) in all prefectures except Okinawa (where it was $811). In comparison, the rise was more limited in the rich urban prefectures, where the new manufacturing industries tended to concentrate. This indicates that rural areas benefited from the spillover effects of industrialization, in particular due to the surge in demand for agricultural products.

The evolution of per capita GPP for 1925, 1935, 1940, and 1950 is presented in Figure 2.4. By 1935, in spite of economic hardship in rural areas resulting from the drastic drop in agricultural prices in the aftermath of the 1929 crisis,[19] per capita GPP was lower than in 1925 only in a number of prefectures that were highly specialized in silk production. These areas suffered disproportionately from the collapse in demand for silk products in both the domestic and international markets (in particular in the United States). Nevertheless, per capita GPP was above $1,095 in all prefectures except Okinawa, where it was

[18] Hokkaido, at this time a frontier area that had just been opened for land reclamation, had abundant natural resources and hence a large stock of natural capital per head, so it was a special case.

[19] On the deterioration in the agricultural terms of trade due to the decline in agricultural prices during the Great Depression, see Odaka (1989: 146–151).

Figure 2.4 Per capita GPP in 1990 US dollars: 1925, 1935, 1940, and 1950



Note: Per capita GPP in national prices in 1925, 1935, and 1940; per capita income adjusted for regional price differences in 1950 (see Appendix 2, Section A2.7, for more information).
Sources: This study for 1925, 1935, and 1940; KKKK (1956) for 1950.

$980.

The period of rapid economic growth and industrialization of the second half of the 1930s resulted in further improvements in all prefectures. By 1940, per capita income was close to or above $1,460 (i.e., four times the subsistence level) in all prefectures except Okinawa, where it was $1,364. In 1940, according to Maddison's estimates, per capita GDP stood at $1,600 in Korea and $1,507 in the Philippines, while in all other Asian countries it was below $1,300. Living standards in the poorest Japanese prefectures were therefore close to the national averages for the richest Asian countries.

The evolution of living standards after 1955 is well documented, both at the national and regional level. By 1955, the Japanese economy had already recovered as a result of the positive demand shock brought about by the Korean War (1950–1953). However, only very limited information on prefecture-level per capita income is available for the wartime and immediate post-war periods. In order to assess regional differences at the onset of the Korean War and changes in liv-

ing standards between 1940 and 1950, we use prefecture-level estimates of per capita income in current yen adjusted using regional prices of a basket of goods and services.[20] These estimates of per capita income in national prices are then converted into 1990 US dollars using Maddison's national average per capita GDP figure for 1950.

Ideally, we would like to compare regional differences in 1940 and 1950 using per capita GPP for both years, but it is currently impossible to generate estimates for 1950 due to data limitations. We therefore use per capita income in 1950 as proxy for per capita GPP. The gap between GPP estimates based on a production approach and prefectural income may be sizeable. Because a sizable share of revenues originating from agriculture, mining, and manufacturing was received by non-residents, per capita GPP figures tend to understate living standards in the richest prefectures, particularly in the inter-war period, when national-level personal income inequality reached historical peaks.[21] In particular, cross-prefecture revenue flows from mining and manufacturing contributed to high income levels in Tokyo and Osaka, where large companies were incorporated and major stockholders were resident. An additional consideration, specific to that period, is that the dissolution of the *zaibatsu* (business conglomerates) and the land reform of 1947 led to a spatial reallocation of incomes.[22]

Keeping these limitations in mind, we can nevertheless identify regional differences in the impact of WWII on living standards. Although per capita income in Tokyo in 1950 was only slightly lower than per capita GPP in 1940, a drastic decline in living standards can be observed for the other major urban and industrialized prefectures,

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[20] We calculated price differences using unit price data for a number of foodstuffs and consumer services (see Appendix 2, Section A2.7, for details on the source and the composition of this basket).

[21] This is evidenced at the national level by measures of the shares of top incomes as a percentage of total income estimated by Moriguchi and Saez (2008) using fiscal data.

[22] Most higher income households drawing much of their income from assets resided in the most urbanized prefectures, as evidenced by information on top taxpayers in 1936 reported by Yazawa (2004). Similarly, a number of major owners of agricultural land (particularly absentee landlords in eastern Japan) or forested land (including the Imperial Household) also resided in the most urbanized prefectures.

in particular Yokohama, Aichi, Kyoto, Osaka, Hyogo, Hiroshima, and Fukuoka. By contrast, in a number of rural prefectures of eastern Japan that had a structural output surplus of staples, particularly in northern Honshu, per capita income in 1950 appears to have been only marginally lower than in 1940. However, in a number of rural prefectures in western Japan, particularly in southern Kyushu, per capita income in 1950 was not only below the level in 1940 but even below that in 1925.

Next, let us consider the regional evolution of living standards using other indicators of well-being, namely, the average height of male adults calculated using information on military conscripts, which we already used in the previous section to gauge regional inequality, and the share of rice in staple consumption (Figure 2.5). Rice was by far the most expensive staple and the preferred one, and was the standard staple in urban areas, along with some wheat processed as noodles. It accounted for a large share of rural households' consumption expenditures (when taking into account self-consumption in the estimation of total consumption) and was also the most important staple in terms of cross-prefectural trade.[23]

Information on rice shares at the prefectural level is obtained from the report on a survey, undertaken in 1886, on the composition of staple foods consumed by rural commoners (Umemura, Takamatsu, and Itoh, 1983: 246-247). At the national level, rice accounted for around 53% of rural commoners' staple consumption in volume, with the rest coming from cheaper and generally less preferred staples (barley, wheat, but also millet, buckwheat, along with sweet and white potatoes). The standard diet of rural dwellers was a mix of different grains (including some beans) that were barely processed.

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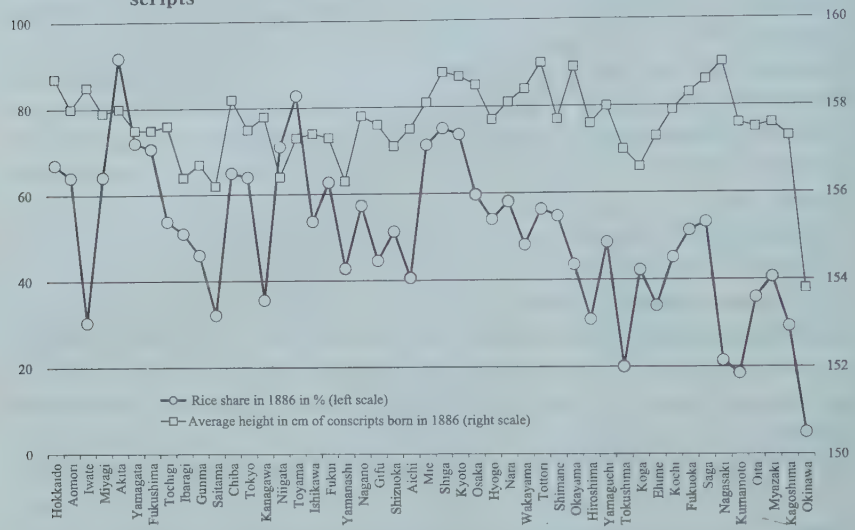
[23] Matsumoto (2004) provides detailed information on cross-prefectural trade in rice in 1905, showing that the total volume was 7.58 million *koku* of rice (1 *koku* = 180 liters or around 150kg of husked rice), while total national output was 38.11 million *koku* (Matsumoto, 2004: 124-125, 121, and 112). Total cross-prefectural flows therefore accounted for around 20% of total output. This is comparable to the figure for the early 19th century: according to estimates by Miyamoto (1985: 208) out of a total average annual output of 6.75 million *koku*, a volume of 6.75 million *koku* was collected as taxes, of which 4.45 million *koku* were available for sale, that is, around 16% of total rice output.

Figure 2.5 Share of rice in staple consumption and average height of army conscripts



Note: The 1886 survey of consumption does not provide information on Okinawa. The value for Okinawa therefore is estimated based on production data for the late 19th century, which indicate that sweet potatoes accounted for around 90% of staple production in Okinawa and rice for only 5%.

Sources: The share of rice is taken from Umemura, Takamatsu, and Itoh (1983: 246–247). The height data are from conscription reports for 1906. See Bassino (2006a) for a further discussion of regional height inequality in pre-war Japan and for detailed information on data sources.

The 1886 survey indicates that sizable regional differences existed in the rice consumption of rural commoners, who accounted for a large majority of the population until the early 20th century. Unsurprisingly, rice accounted for 92% and 71% of the staple consumption of commoners in Akita and Niigata, major rice-producing prefectures in the northwest of Honshu island. Similarly, in Shiga prefecture, another "rice basket" located close to Kyoto, the share was 75%. On the other hand, in Tokushima prefecture on Shikoku island, the share was only 20%, in Kagoshima prefecture in the southern part of Kyushu island it was 29%, and in Iwate prefecture in the northeastern part of Honshu island 30%. The share of rice in staple consumption was particularly high in regions that had a structural surplus and in urban areas.

A rising share of rice in staple consumption is observed in the 20th

century. This reflects the improvement in living standards. Before the end of World War I, the major part of the rice consumed in Japan was domestically produced.[24] This was made possible by the diffusion from the prefectures of western Japan with the highest yields of selected rice varieties and improved cultivation techniques to more laggard regions of eastern Japan. This diffusion process played a major role in the increase of rice output in the 1890s and 1900s (Yamada and Hayami, 1979a, 1979b). The rise in the share of rice in agricultural output contributed to the increase in per capita GPP, particularly in some of the poorest rural prefectures in eastern Japan.

Turning to height differences, as already mentioned in Section 2.2, we find that prefectural average height in the late 19th century is highly correlated with prefectural per capita GPP. The rise in per capita GPP observed since the late 19th century is mirrored in a spectacular upward trend in stature, from a very low initial level. These improvements were experienced in all prefectures and were interrupted only temporarily by World War II and the resulting collapse of the Japanese economy. Prefecture-level data of height for army conscripts indicate that the average height of Japanese male adults aged 20 reported in conscription reports ranged from 154.4 cm (Kagawa) to 158.4 cm (Hokkaido) for the cohort born in 1874 (measured in 1894)[25] and from 158.1 cm (Okinawa) to 163.1 cm (Kyoto) for the cohort born in 1909 (measured in 1929). A similar upward trend is observed for students in all prefectures since the pre-WWII period.[26]

In this section, we examined developments in living standards in absolute terms by looking at per capita GPP figures in constant 1990 international dollars, which made it possible to compare living standards in late-19th and early 20th century Japan with those in Europe and other Asian countries. The figures indicate that in 1874, per capita GPP was already well above the World Bank absolute poverty line of $1 a day in all prefectures. Moreover, although per capita GPP in the

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[24] Rice imported from Korea and Taiwan began to account for a significant part of Japanese consumption only from the late 1910s.

[25] Data for army conscripts from Okinawa are available only for cohorts born from 1878; judging from these data, average height in Okinawa in 1874 was probably lower than in Kagawa.

[26] The sources for prefecture-level data are described in Table 2.2.

late 19th century even in the richest prefectures was well below the per capita GDP levels of Western European countries, living standards in Japan were well above those of most other Asian countries, in particular China and India. In the first half of the 20th century, living standards across Japan improved markedly during two phases: between 1909 and 1925, mostly due to the rapid development of manufacturing activities during WWI, and between 1935 and 1940 in the context of the rapid expansion of high-tech industry. In both periods, living standards rose substantially in most prefectures. By contrast, WWII had a more differential impact, with long-lasting consequences in the most urbanized and industrialized areas of western Japan that had been the main gateways to the Japanese colonial empire. The rise in per capita GPP in the late 19th and early 20th century was associated with an increase in the share of rice in the diet of residents of prefectures where it was initially the lowest; in parallel, the improvement in living standards was reflected in a steady upward trend in stature in all prefectures.

2.4 Prefectures' relative fortunes and rank stability

This section looks at trends in prefectures' relative fortunes over the course of Japan's economic development by examining their relative ranking in terms of per capita GPP over time.

The overview of prefectures' per capita GPP presented in Section 2.3 suggests that some prefectures, such as Tokyo, have always been at the "top," while the relative fortunes of other prefectures have changed over time. This raises the question to what extent prefectures' relative position has been stable over time, which, in turn, provides an indication of the extent to which the regional pattern of economic development has been path-dependent and may even tell us about the forces driving Japanese development since the late 19th century. To examine these issues, we use rank order correlation coefficients devised by Spearman and Pearson to measure changes in the ranking of prefectures in terms of per capita GPP (adjusted for regional price differences, i.e., at purchasing power parity) over different time spans.

Table 2.3 shows the results for our observation period as a whole (1874–2008), for the pre-war (1874–1940) and the post-war period

Table 2.3 Rank order correlations of per capita GPP adjusted for regional price differences

	Pre-war					Pre-war total
	1874–1890	1890–1909	1909–1925	1925–1935	1935–1940	1874–1940
Spearman's rho	0.69	0.81	0.77	0.57	0.76	0.49
p-value	0.00	0.00	0.00	0.00	0.00	0.00
Pearson	0.82	0.91	0.95	0.67	0.91	0.49

	Word War II	Post-war			Post-war total	Whole period
	1940–1955	1955–1970	1970–1990	1990–2008	1955–2008	1874–2008
Spearman's rho	0.73	0.92	0.83	0.92	0.75	0.26
p-value	0.00	0.00	0.00	0.00	0.00	0.10
Pearson	0.82	0.91	0.78	0.93	0.69	0.28

Source: See text.

(1955–2008), and for various sub-periods. The results indicate that even for the entire observation period (1874–2008), Spearman's rho for rank-order correlation is statistically significant and takes a value of 0.26, indicating that the relative position of a quarter of prefectures remained unchanged. For shorter intervals, the correlations are naturally higher. Looking at the pre-war and post-war periods separately, the values are 0.49 and 0.75 respectively.

These results indicate that there has been considerable stability in prefectures' relative position in the ranking—even over the long period from 1874 to 2008. This pattern is very different from the one observed, for example, for Sweden. Conducting a similar exercise for Sweden's counties for the period 1860–2000 and for 20- to 40-year intervals within this period, Enflo and Rosés (2014) find that although the rank correlations for the sub-periods are significant, that for the period overall is zero. They argue that this reflects the changing fortunes of various regions due international demand for natural resources in which some of the regions specialized. In contrast, the considerable stability we observe for Japan conforms with the notion that prefectures like Tokyo and Osaka have consistently had among the highest per capita GPP, while prefectures like Okinawa and

Kagoshima have consistently had among the lowest.

Furthermore, it reflects the fact that, unlike in Sweden for example, natural resources have played only a minor role in shaping the economic fortunes of regions in Japan. A notable exception is Hokkaido, which was only "opened up" in the late 19th century and rapidly became one of Japan's leading agricultural and mining regions during the pre-war period. However, as the importance of agriculture and mining in the overall economy declined, so Hokkaido's ranking fell dramatically: while the prefecture was usually among the ten wealthiest prefectures in terms of per capita GPP in the pre-war period, by 2008 it had dropped to only 34th place.

Apart from Hokkaido, other prefectures that saw a huge relative decline are Kochi (both during the pre-war and the post-war period, from 6th place in 1874 to 20th in 1940, and then to 44th in 2008) and Yamagata (pre-war decline from 11th place in 1874 to 43rd in 1940, followed by a slight recovery to 37th in 2008), while prefectures that saw a particularly large rise in their ranking include Shizuoka (33rd place in 1874 to 21st in 1940, and 3rd in 2008), and Hiroshima (29th to 9th, steady rise pre- and post-war). However, looking at the rank correlations and the ranks of individual prefectures over time confirms the perception that economic activity has gravitated more and more to the Kanto-Kansai corridor. Specifically, both Tokyo and Osaka have consistently been among the top three economic regions throughout the entire observation period. However, by 1990, Osaka had been demoted from second to third place by the rise of Aichi prefecture, whose capital, Nagoya, became the center of a major industrial agglomeration during the inter-war period.

One of the main findings of this section is that, with the exception of a few prefectures such as Hokkaido and Shizuoka, the ranking of Japanese prefectures remained fairly stable over time, particularly in the post-WWII period. This stability indicates considerable path dependence in the regional pattern of Japan's economic development, suggesting that agglomeration economies, coupled with geographic factors, have played an important role in reinforcing the spatial distribution of economic activity.

2.5 Japanese regional inequality and convergence in international perspective

The analysis in Section 2.2 suggested that regional inequality in Japan, as in most other countries over their course of economic development, was characterized by an inverted U curve. However, this tells us little about the relative extent of regional inequality in Japan when compared with other countries. On the one hand, given that Japan was characterized by a high degree of political fragmentation until 1868 and incomplete market integration until the late 19th century, it would not be unreasonable to assume that regional inequality was comparatively high by international standards. On the other hand, it could also be said that the rise in regional inequality during the upward-sloping phase of the inverted U curve between 1874 and 1910 appears to have been relatively limited, which may be linked to the concurrent process of political centralization and market integration.

In order to evaluate the overall level of regional inequality in Japan, we cast the Japanese experience in international perspective by comparing it with other countries at the same level of economic development. To this end, this section relies on available evidence on historical patterns and determinants of regional divergence and convergence in the United States and Europe. In the United States and most European countries, an inverted U curve (Kuznets, 1955; Williamson, 1965) can be observed, with turning points around 1860 in the United States and in the early or mid-20th century in several European countries (Williamson, 1965). However, our main objective is to compare the levels of regional inequality, again using the coefficient of variation. The calculation of the CVs is based on data reported by Crafts (2005) for Britain, Felice (2011) for Italy, and Martínez-Galarraga, Rosés, and Tirado (2013) for Spain. For the United States, figures before 1929 are from Eldridge and Thomas (1964), while figures from 1929 onward are from the website of the Bureau of Economic Analysis, US Department of Commerce (http://www.bea.gov/regional/index.htm). Further, in order to check to what extent the size of territorial units affects the results for European countries and also to provide a more meaningful comparison with countries with large populations such as China and the United States, we also calculate CVs for Europe using

the per capita GDP of 14 countries reported in Maddison (2003). The list of countries included is dictated by data availability.[27]

We also include China in the comparison, but only from 1949 onward, using information for "first class administrative districts"[28] (which we refer to as "provinces" hereafter). There are currently no dependable estimates of regional GDP or income for pre-war China. The coefficient of variation is calculated using data from Department of Comprehensive Statistics, National Bureau of Statistics of China (1999) before 1993, while figures from 1993 onward are from Department of National Accounts, National Bureau of Statistics of China (2007). It is likely that available estimates of provincial income for China were not adjusted for regional price differences and do not include self-consumption of foodstuffs by rural households. When per capita provincial GDP for the 1950s and 1960s is converted into 1990 US dollars using the series provided by Maddison (2003) for China as a whole, it turns out that per capita GDP is below $400 in a number of provinces, and in some cases even below $300. In order to adjust for the probable underestimation of self-consumption, we therefore increased all figures by adding $200 per capita for all provinces and all years. The CV weighted by population is around 20% higher without this adjustment in the first three decades covered by the series, but the effect fades as a result of the rapid rise of living standards from the 1980s.

It should be also noted that, when comparing the results for these countries, the degree of regional inequality, and hence the CV, is affected by the way these countries are divided into administrative units as well as the size of their territory. With that caveat in mind, for Japan we used the CV of regional inequality for 47 prefectures as well as for 14 regions. The CV for 14 regions for Japan is used for the comparison with Britain (11 regions), while the CV for 47 prefectures appears more relevant for the comparison with Italy (16 to 20 regions), Spain (18 regions), and China (where the number of prov-

[27] The 14 European countries are Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. The list is constrained by data availability from the 1870s in the database compiled by Maddison (2003).

[28] These districts include major cities such as Beijing, Shanghai, and Tianjin.

inces rose from 27 in 1952 to 31 in 1999).

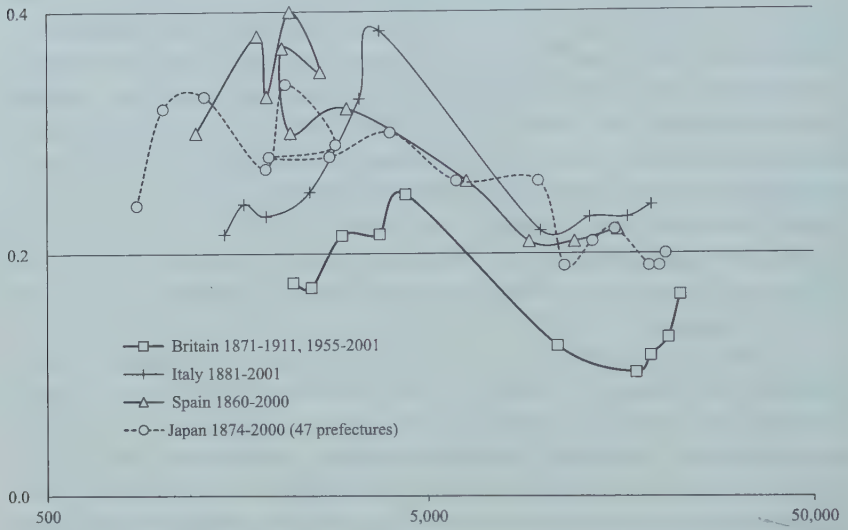
It should further be noted that for pre-war Britain and Spain, divergence and convergence are assessed using income estimates obtained indirectly using an income approach, while the estimates for pre-war Italy were calculated using a production approach and are therefore more comparable to our estimates for pre-war Japan. There is unfortunately no easy way to adjust these series. It is likely that, in the process of industrialization, regional inequality in per capita income increased faster than in per capita GDP due to the rise of large companies with operations in different regions. The headquarters and shareholders of these companies were usually located in one of the core urban regions.

In order to facilitate the international comparison, per capita income is adjusted for differences in purchasing power. For that purpose, we use national real per capita GDP in 1990 international Geary-Khamis dollars based on Maddison's (2003) estimates, which in our figures comparing developments in the different countries we plot on the horizontal axis, while the CV is shown on the vertical axis. Specifically, Figure 2.6 shows a comparison between Japan, Britain, Italy, and Spain, and Figure 2.7 a comparison between Japan, China, Europe, and the United States.

The relationship between economic development and regional inequality in Japan appears to be relatively similar to that in the United States, Italy, and Spain, as well as for the 14 European countries together. All these countries (and Western Europe as a whole) had already attained a high degree of market integration in the mid-19th century and are therefore comparable to Japan from that viewpoint. Overall, Japan appears as an Asian country following a trend of regional inequality comparable to that of Western countries during the process of economic transformation.

By contrast, regional inequality in China, in terms of the coefficient of variation, is considerably greater than that experienced in the United States, the European countries, or Japan in the past. Reasons for this large regional inequality in China include the fact that for a long time, there were restrictions on rural-urban migration and that although such restrictions have been relaxed in recent years, factors remain, especially with regard to the education of the young, that impede rural-urban migration. Such formal restriction did not exist in

Figure 2.6 Economic development and regional income inequality in Japan (47 prefectures) in comparison with Britain, Italy, and Spain



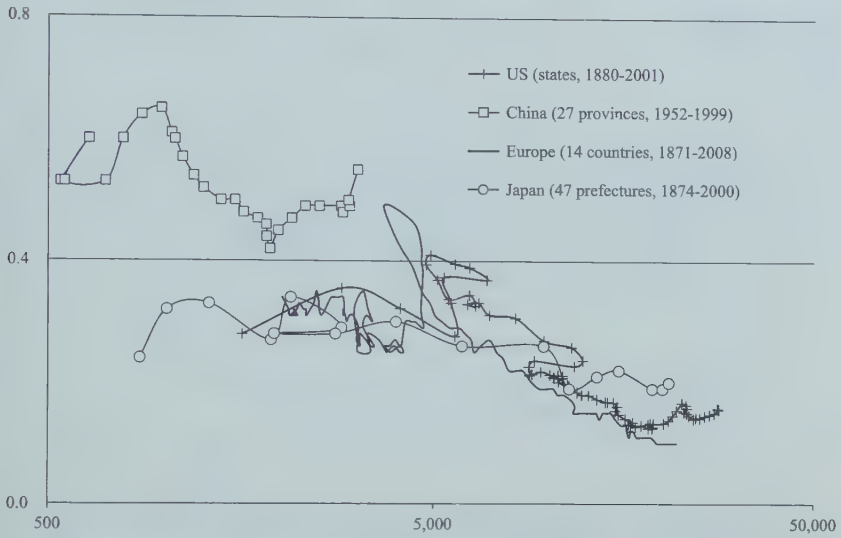
Note: The vertical axis shows the CV, while the horizontal axis depicts per capita GDP/income in 1990 US dollars.
Sources: See text.

Japan. As will be discussed in Chapter 4, population flows across prefectures played an important role in regional convergence both before and after WWII.

In the case of China, with the exception of the period of the Cultural Revolution from 1967 to 1978, when the coefficient of variation for per capita gross provincial product rose rapidly, the long-term trend is generally also one of declining inequality. Owing to the lack of estimates for the pre-war period, one can only conjecture that regional inequality was rising in the first half of the 20th century as a result of the expansion of commercial activities in coastal China and the development of manufacturing production in a few areas, mostly around Shanghai and in the northeastern provinces. Since 1990, when the coefficient of variation (for per capita gross provincial product) recorded a post-war low, the trend has reversed and regional inequality has increased again.

One of the major similarities between Japan and Western coun-

Figure 2.7 Economic development and regional income inequality in Japan (47 prefectures) in comparison with China, European countries, and the United States



Notes: The vertical axis shows the CV, while the horizontal axis depicts per capita GDP/income in 1990 US dollars. The figures are population weighted. GDP series for China were adjusted for the underestimation of self-consumption (see text).
Sources: See text.

tries is that the geographic mobility of labor was not constrained by political institutions, as opposed to the situation that prevailed in China in the second half of the 20th century. In Japan, as well as Europe and the United States, the absence of barriers to mobility resulted in massive migration flows in the late 19th and 20th centuries. This issue is discussed further in Chapter 4. A related issue is the role of migration as a possible explanatory factor for the low level of regional inequality in Japan in the early Meiji period. Formal barriers to labor migration across feudal domains imposed by feudal lords during the Tokugawa period (1603–1868) did not prevent the mobility of skilled and unskilled workers, as workers did migrate in numbers, either upon request of their feudal lord for construction projects in Edo or elsewhere, or under the pretext of pilgrimage (Vaporis, 1994). It is, however, impossible to assess the magnitude of these flows and their contribution to the reduction of regional differences in per capita income.

2.6 Conclusion

The main results obtained in this chapter can be summarized as follows:

- A long-term trend of an inverted U curve in the population-adjusted coefficient of variation of per capita income is observed for Japan up to the 1970s. However, the CV increased again in the 1980s, particularly during the years of the economic bubble and, after reverting to a low level in the 1990s, again in recent years.
- Living standards were already well above subsistence level in 1874 and afterwards remained on an almost continuously rising trend, the major exception being WWII.
- Prefectures' ranking in terms of their per capita GPP was quite stable over time.
- The Japanese economy has been characterized by a low degree of regional inequality in comparison with China, but the relationship between economic development and regional inequality in Japan appears to be relatively similar to that in the United States and European countries.

The analysis presented in this chapter provides an overall picture of developments in regional inequality in Japan since 1874. The picture that emerged is one of an inverted U curve in the coefficient of variation of prefectural income, with the level of regional inequality being comparable to that in the United States and European countries at similar levels of development, but much lower than in China. From the early 20th century, Japan followed an almost continuous trend of regional convergence. It appears that convergence accelerated in the phase of rapid development of the manufacturing sector. Underlying these overall developments are a host of other developments driving them, such as developments in labor productivity and industrial structure as well as migration. The following two chapters address these issues in turn.

Chapter 3

Industrial Structure, Prefectural Inequality, and Convergence

3.1 Introduction

The analysis of inequality in per capita gross prefectural product (GPP) in the preceding chapter showed that such inequality was relatively low at the start of Japan's modern economic growth in the early years of the Meiji period. However, prefectural inequality (as measured by the coefficient of variation, CV, in per capita GPP) increased from 1874 to 1890 during the first so-called "enterprise boom" (*kigyo bokko*, 1886–1890) and continued to rise at a somewhat slower pace during the second and third enterprise booms (1895–1900 and 1905–1910) between 1890 and 1909. The trend reversed during World War I and the subsequent recession in the following subperiod from 1909 to 1925, but inequality rose again during the following decade, which was characterized by economic turmoil and high inflation due to expansionary fiscal and monetary policies from 1931 to 1936 under finance minister Korekiyo Takahashi, before declining between 1935 and 1940 reflecting the transition to a wartime economy.[1]

Following the hiatus of World War II, prefectural inequality

[1] Why prefectural income inequality declined during the period 1909–1925, i.e., the period comprising World War I, is of considerable interest and deserves further research in the future.

declined rapidly during the high-speed growth era from 1950 until the early 1970s, but then increased again somewhat during the period of stable growth during the late 1970s/early 1980s as well as the bubble economy in the second half of the 1980s. Prefectural inequality declined again during the first half of the 1990s following the burst of the bubble economy and has remained more or less unchanged since the mid-1990s. Overall, therefore, regional inequality in Japan, as measured by the population-weighted CV in GPP per capita, more or less follows an inverted U curve with some fluctuations, with inequality peaking sometime during the first few decades of the 20th century (see Figure 2.1 in the previous chapter).

The aim of the present chapter is to examine the factors underlying these trends in prefectural inequality focusing on prefectural differences in industrial structure and developments therein, concentrating in particular on the pre-war period. However, before looking at prefectural differences in industrial structure, it is useful to provide an overview of changes in Japan's industrial structure overall, which we do in the next section (Section 3.2). This is followed by an examination of prefectural differences in industrial structure (Section 3.3). Next, Section 3.4 presents a decomposition of differences in GPP per capita into prefectural differences in industrial structure and differences in labor productivity within the same industry. Finally, Section 3.5 provides a summary of the findings of this chapter.

3.2 Long-term trends in Japan's industrial structure

To gain a sense of trends in Japan's industrial structure over the course of its economic development, Tables 3.1(a) to (c) provide various indicators for our benchmark years for the country as a whole. While the tables present data for the entire period from 1874 to 2008, in the discussion here we will confine ourselves primarily to the pre-war period. Let us begin by looking at sectoral shares in value added overall (Table 3.1(a)). As can be seen, at the start of our observation period in 1874, the primary sector accounted for roughly 60% of output, the secondary sector for 10%, and the tertiary sector for 30%, indicating that at the start of the Meiji period Japan was still an agrarian economy. However, the primary sector share declined steadily throughout the pre-war period, falling to 18% in 1940 and, conversely,

the secondary sector share gradually rose to more than 40%, while the share of the tertiary sector remained relatively stable in a range of 30–40%. Although the primary sector share immediately after the war was somewhat higher than in 1940, it then continued to fall rapidly throughout the rest of the period, so that by 2008, the primary sector accounted for less than 2% of national output. On the other hand, the output shares of the secondary and tertiary sectors expanded considerably during the high-speed growth era. However, whereas the secondary sector share peaked sometime around 1970 and subsequently contracted, the share of the tertiary sector continued to increase, so that in 2008 it accounted for almost 70% of total value added.

Looking at labor force shares (Table 3.1(b)), the large role played by the primary sector at the start of our observation period in 1874 is even more pronounced, with the sector accounting for 71% of employment compared to 13% for the secondary and 16% for the tertiary sector. In addition, subsequent trends also differ somewhat from those in the value added shares: while the share of the primary sector declines, the shares of the secondary and tertiary sectors increase at more or less the same pace. Meanwhile, in the post-war period, the expansion of the tertiary sector share is more pronounced than on a value added basis.

Finally, Table 3.1(c) shows labor productivity levels and growth rates measured in terms of value added per gainfully occupied person based on the data in Tables 3.1(a) and (b). In this context, it is important to note that the data on the gainfully occupied population in Table 3.1(b) take by-employment into account.[2] The process of rural industrialization during the latter half of the Edo period meant that many farm households were engaged in by-employment in production activities in the secondary sector, such as silk-reeling and weaving, and this pattern continued after the Meiji Restoration.[3] This means that if we were to classify gainfully occupied persons simply based on their principal occupation, the labor input for goods produced through such by-employment would not be measured, so that labor productivity in the primary sector would be underestimated, while labor productivity in the secondary and tertiary sectors would be overestimated.[4]

Looking at the results in Table 3.1(c), the first thing to note is that labor productivity in the primary and secondary sectors in 1874

was almost identical, while that in the tertiary sector was more than twice as high as in the other two sectors. Moreover, even in 1890, when industrialization was well underway, labor productivity in manufacturing and construction was still essentially the same as in the primary sector (agriculture, forestry and fisheries). This indicates that, as already argued by Saito (2008, 2013) and Sugihara (2013), Gerschenkron's (1962) relative backwardness hypothesis, which suggests that more backward countries experience larger labor productivity differences between traditional and modern industries in the early stages of industrialization, does not hold in the case of Japan, which followed a path of labor-intensive industrialization based on the development of rural industry during the Edo period.

Let us consider developments in labor productivity during the pre-war period in more detail. Highlighting that employment in agriculture during much of the pre-war period remained constant at 14

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[2] That being said, it should be noted that the way by-employment is taken into account differs for the pre-war and post-war periods. For the pre-war period, the gainfully occupied population is calculated by assuming that those engaged in by-employment divide their time equally between their principal occupation and their by-employment, and they are counted as "half a worker" in each sector in which they are employed. This means that there is no double-counting of gainfully occupied persons (Saito and Settsu, 2010). On the other hand, for the post-war period, we used the employment figures of the JIP Database, where no such adjustments are made, so that persons employed in two different sectors are counted twice when summing up the total number of gainfully occupied persons across sectors. This means that we would underestimate labor productivity if we used the employment data as they are. However, since, as explained by Fukao and Miyagawa (2008), labor productivity in the JIP Database is calculated on a man-hour basis, we can allocate double-counted persons using detailed information on their working time, allowing us to eliminate this problem.

[3] For a further discussion of rural industrialization (proto-industrialization) during the Edo period, see Appendix 1.

[4] See Saito and Settsu (2010) for details. It should be noted that this is the case because in Japan the typical pattern was for those principally occupied in farming to have by-employment in another sector. If the pattern were different and many who were principally employed in the secondary or tertiary sector had by-employment in agriculture, the implications for the estimation of labor productivity would be different.

Table 3.1 Value added, employment, and labor productivity by sector

(a) Value added (output) by industry (in 1,000 yen for 1874–1940 and million yen for 1955–2008)

GDP and sectoral share in current prices

	GDP	Agriculture	Forestry	Fisheries	Mining	Manufacturing	Construction	Domestic trade and service industries	Transport, communication, and utilities	Total
1874	728,724	49.31%	7.16%	2.15%	0.57%	7.45%	2.88%	30.48%		100.00%
1890	1,224,063	37.77%	5.16%	1.56%	1.12%	12.20%	2.97%	36.91%	2.30%	100.00%
1909	4,028,122	27.20%	4.84%	1.53%	2.57%	16.55%	3.99%	36.55%	6.77%	100.00%
1925	18,154,468	21.88%	3.22%	1.49%	1.95%	19.21%	4.84%	35.07%	12.35%	100.00%
1935	19,238,524	13.30%	1.93%	1.19%	2.62%	27.02%	5.32%	36.30%	12.32%	100.00%
1940	38,021,539	12.59%	3.64%	1.31%	3.52%	31.59%	7.39%	29.19%	10.77%	100.00%
1955	8,286,675	18.58%			1.96%	32.10%	4.59%	32.84%	9.93%	100.00%
1970	68,911,619	6.02%			0.89%	37.95%	8.26%	37.14%	9.74%	100.00%
1990	406,485,348	2.46%			0.26%	28.52%	10.51%	49.05%	9.20%	100.00%
2008	442,078,644	1.47%			0.07%	22.86%	6.64%	59.73%	9.24%	100.00%

In constant prices (1874–1940: average of prices in 1934–1936; 1955–2008: prices in 2000)

1874	3,946,854	1,466,650	212,845	63,971	13,242	211,138	57,821	1,921,187	
1890	5,279,794	1,626,737	217,000	75,062	34,243	459,757	127,300	2,666,994	72,700
1909	8,201,001	2,235,884	305,100	79,416	149,552	1,009,122	291,000	3,676,427	454,500
1925	14,597,585	2,725,099	361,400	179,656	282,410	2,439,079	594,000	6,115,942	1,900,000
1935	19,010,553	2,541,677	381,500	228,739	417,423	5,247,644	1,028,000	6,680,569	2,485,000
1940	24,360,850	2,461,313	584,400	220,822	633,127	7,229,061	1,408,000	8,831,128	2,993,000
1955	53,883,712	8,039,866			304,741	8,108,567	6,221,177	28,326,390	2,882,972
1970	191,606,178	8,432,721			961,710	47,407,917	32,156,827	86,081,450	16,565,553
1990	415,148,700	9,282,027			914,571	106,059,520	48,780,802	213,249,876	36,861,903
2008	523,620,729	8,142,102			315,093	149,840,662	30,202,276	281,580,085	53,540,511

Note: Okinawa is excluded in 1955 and 1970.

(b) Gainfully occupied persons (taking by-employment into account)

Total number of persons and sectoral share

	Total number of persons	Agriculture and forestry	Fisheries	Mining	Manufacturing and construction	Commerce	Other services	Transport, communication, and utilities	Total	Total population
1874	21,745,206	70.96%		12.71%			16.33%		100.00%	34,840,434
1890	23,263,244	58.25%	1.74%	0.63%	20.33%	9.92%	6.58%	2.54%	100.00%	39,876,027
1909	23,299,661	53.76%	2.28%	1.36%	19.95%	12.18%	7.36%	3.12%	100.00%	48,947,737
1925	27,217,303	44.94%	1.79%	1.33%	22.96%	15.89%	8.76%	4.32%	100.00%	59,985,602
1935	31,596,012	41.06%	1.75%	1.17%	23.48%	17.84%	11.00%	3.70%	100.00%	69,466,361
1940	33,275,036	39.03%	1.57%	2.05%	26.35%	16.25%	10.53%	4.23%	100.00%	71,868,772
1955	40,763,353	41.35%		1.09%	23.38%	11.75%	17.45%	4.98%	100.00%	89,270,945
1970	54,259,458	19.86%		0.43%	33.95%	15.48%	24.13%	6.15%	100.00%	103,725,580
1990	64,262,899	8.79%		0.15%	32.76%	16.22%	35.76%	6.31%	100.00%	123,608,423
2008	64,202,212	5.01%		0.06%	25.39%	14.98%	48.13%	6.42%	100.00%	127,692,273
Annual growth rate in the number of gainfully occupied persons										
1874–1890	0.42%	−0.63%		3.55%			1.38%			0.84%
1890–1909	0.01%	−0.41%	1.44%	4.00%	−0.09%	1.09%	0.60%	1.08%		1.08%
1909–1925	0.97%	−0.15%	−0.53%	0.84%	1.85%	2.64%	2.07%	3.02%		1.27%
1925–1935	1.49%	0.59%	1.25%	0.26%	1.72%	2.65%	3.76%	−0.08%		1.47%
1935–1940	1.04%	0.02%	−1.09%	12.17%	3.34%	−0.84%	0.16%	3.72%		0.68%
1940–1955	1.35%	1.48%		−2.84%	0.55%	−0.80%	4.72%	2.44%		1.45%
1955–1970	1.91%	−2.98%		−4.28%	4.39%	3.74%	4.07%	3.32%		1.00%
1970–1990	0.85%	−3.23%		−4.32%	0.67%	1.08%	2.81%	0.97%		0.88%
1990–2008	−0.01%	−3.13%		−4.93%	−1.42%	−0.45%	1.64%	0.09%		0.18%

Notes: Utilities are included in manufacturing before 1940. Other services consist of public administration, self-employed professionals, domestic servants, etc. Growth rates are calculated as log differences. Okinawa is excluded in 1955 and 1970.

(c) Labor productivity (output per gainfully occupied person: in yen for 1874–1940: in 1,000 yen for 1955–2008)

Current prices

	All industries	Primary sector			Secondary sector			Tertiary sector	
		Agriculture	Forestry	Fisheries	Mining	Manufacturing	Construction	Domestic trade and service industries	Transport, communication, and utilities
1874	34	28			29			63	
1890	53	39		39	93	39		118	48
1909	173	103		36	327	178		323	375
1925	667	373		127	982	699		949	1,906
1935	609	226		489	1,360	839		766	2,031
1940	1,143	475		439	1,965	1,691		1,245	2,912
1955	203	91			365	319		229	406
1970	1,270	385			2,609	1,729		1,191	2,012
1990	6,325	1,771			10,788	7,535		5,968	9,229
2008	6,886	2,013			7,161	7,997		6,517	9,918
Relative productivity level (all industries=1)									
1874	1.00	0.83			0.86			1.87	
1890	1.00	0.74		0.74	1.76	0.75		2.24	0.90
1909	1.00	0.60		0.21	1.89	1.03		1.87	2.17
1925	1.00	0.56		0.19	1.47	1.05		1.42	2.86
1935	1.00	0.37		0.80	2.23	1.38		1.26	3.33
1940	1.00	0.42		0.38	1.72	1.48		1.09	2.55
1955	1.00	0.45			1.79	1.57		1.12	2.00
1970	1.00	0.30			2.05	1.36		0.94	1.58
1990	1.00	0.28			1.71	1.19		0.94	1.46
2008	1.00	0.29			1.04	1.16		0.95	1.44

(c) Labor productivity (output per gainfully occupied person: in yen for 1874–1940; in 1,000 yen for 1955–2008) (contd.)
Constant prices (1874–1940: average of prices in 1934–1936; 1955–2008: prices in 2000)

	All industries	Primary sector			Secondary sector			Tertiary sector	
		Agriculture	Forestry	Fisheries	Mining	Manufacturing	Construction	Domestic trade and service industries	Transport, communication, and utilities
1874	182	113			102			541	
1890	227	136		186	232	124		695	123
1909	352	203		149	474	280		808	626
1925	536	252		368	781	485		911	1,615
1935	602	225		414	1,126	846		733	2,128
1940	732	235		422	929	985		991	2,129
1955	1,322	477			685	1,504		2,380	1,421
1970	3,531	783			4,107	4,319		4,005	4,963
1990	6,460	1,643			9,260	7,355		6,383	9,094
2008	8,156	2,531			7,748	11,043		6,949	12,994
Annual growth rate									
1874–1890	1.40%	1.23%			1.38%			0.84%	
1890–1909	2.31%	2.10%		−1.14%	3.76%	4.28%		0.79%	8.57%
1909–1925	2.63%	1.36%		5.64%	3.13%	3.45%		0.75%	5.92%
1925–1935	1.15%	−1.13%		1.16%	3.65%	5.55%		−2.18%	2.76%
1935–1940	3.92%	0.80%		0.38%	−3.84%	3.05%		6.03%	0.00%
1940–1955	−0.65%	−0.68%			1.68%	−0.10%		−1.30%	−0.19%
1955–1970	6.55%	3.30%			11.94%	7.03%		3.47%	8.34%
1970–1990	3.02%	3.71%			4.07%	2.66%		2.33%	3.03%
1990–2008	1.29%	2.40%			−0.99%	2.26%		0.47%	1.98%

Notes: Okinawa is excluded in 1955 and 1970. The growth rates for 1940–1955 are based on Mizoguchi (2003).

million, Hayashi and Prescott (2008) have suggested that Japan was slow to make the transition out of agriculture due to institutional barriers in the form of social norms, namely the desire of farmers that one of their children—typically the first-born son—succeed them and continue the *ie* (household). Specifically, employing a two-sector model consisting of agriculture and the rest of the economy, they argue that this barrier impeded economic growth and that in its absence pre-war GNP per capita would have been 32% higher. However, their assumption that farmers work in agriculture and non-farmers work in other sectors of the economy ignores the widespread existence of by-employment. The wage gap between agriculture and the rest of the economy derived from the model (especially at the start of economic development) likely would be smaller than assumed in their study if by-employment were taken into account. Moreover, given the findings on inter-sectoral labor productivity differences above, the key issue appears to be not the insufficient movement of labor from agriculture to non-agricultural sectors but from other sectors to the tertiary sector.[5]

Finally, let us examine labor productivity growth in each sector. In the primary sector, labor productivity increased at an annual average rate of 1.2% from 1874 to 1890. Focusing on agriculture and forestry in the subsequent periods, labor productivity growth accelerated to 2.1% between 1890 and 1909, before slowing somewhat to 1.4%

[5] As argued by Obi (1971; also see Saito, 2008), a farmer's decision whether to quit farming likely depends on the farmer's household income, i.e., including income other than farming income. This means that a model such as that employed by Hayashi and Prescott (2008), which does not consider household income and households' allocation of labor such that agricultural and non-agricultural wages are equalized, does not really lend itself to sufficiently examining the causes why the transition out of agriculture did not occur. A study presenting ample evidence on how much non-agricultural income farm households could earn in the pre-war period that could be used for such an analysis is provided by Sato (2002: chapter 11). Meanwhile, Masui (1969), whom Hayashi and Prescott (2008) also cite, argues that it is only during the post-war period that factory workers' income came to clearly exceed the cost of leaving agriculture for the household head and the heir (eldest son), and that when it did, farmers did leave agriculture and the transition out of agriculture proceeded rapidly (see Tables 1 to 4 in Masui, 1969).

between 1909 and 1925. The reason for these increases in productivity likely is the diffusion of new farming methods and the development of the sericulture industry in line with growing exports of filature. Turning to the secondary sector, labor productivity grew at an annual rate of 1.4% in 1874–1890 (manufacturing, construction, and mining), 4.2% in 1890–1909 (manufacturing and construction), and 3.5% in 1909–1925 (again, manufacturing and construction), suggesting that productivity growth jumped after 1890. On the other hand, the picture in the tertiary sector is very mixed. Productivity growth in domestic trade and services remained below 1% for most of the pre-war period; in stark contrast, transport, communication, and utilities registered extremely high productivity growth rates of 8.6% in 1890–1909 and 5.9% in 1909–1925. This high productivity growth likely reflects the rapid progress in infrastructure development such as the building and improvement of roads and railways.

Productivity growth slowed sharply in the period from 1925 to 1935, which includes the Great Depression, in all industries/sectors except for mining as well as manufacturing and construction (in fact, productivity growth turned negative in agriculture and forestry as well as domestic trade and services). This likely reflects the slump in raw silk thread prices in the United States during the Great Depression and the large shock to the rural economy this imposed.[6]

Taking a brief look at the post-war period, we find that manufacturing and transport, communication, and utilities registered high rates of productivity growth of 7% and 8% respectively during the high-speed growth era until ca. 1970, but productivity growth decelerated almost across the board thereafter. Particularly noteworthy is the slow rate of productivity growth in domestic trade and services from 1990 to 2008 of only 0.5% annually.[7]

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[6] Moreover, as shown by Settsu (2006), during the period of the Great Depression, excess labor was absorbed in the urban small commerce sector, which likely contributed to the decline in productivity growth in the service sector.

[7] This point will be discussed in greater detail in Chapter 5.

3.3 Prefecture-level industrial structures

3.3.1 Trends in prefectures' GPP by industry

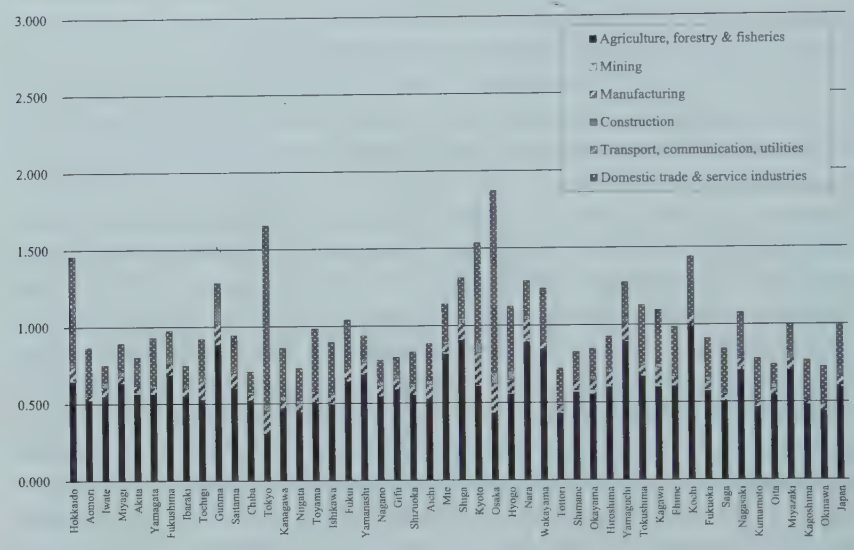
Having looked at changes in Japan's industrial structure overall, let us now examine developments in prefectures' GPP by industry. To this end, Figure 3.1 shows the gross value added per capita in each prefecture broken down by industry relative to the gross value added per capita in Japan as a whole (Japan = 1). We saw earlier that in 1874 the primary sector (agriculture, forestry, and fisheries) accounted for the overwhelming majority of output in Japan overall, and this is also the case for most prefectures. However, taking a closer look, the figure indicates that wealthier prefectures such as Tokyo and Osaka tended to have larger tertiary sector shares, and correlation analysis shows that, as a general rule, prefectures with a high gross value added per capita tended to have a large tertiary sector share.[8] Exceptions to this rule are Gunma, Shiga, Nara, Wakayama, Yamaguchi, and Kochi, where the share of the primary sector was larger than that of the tertiary sector, but per capita value added was nevertheless relatively high. However, the contribution of the primary sector to per capita value added in these prefectures subsequently declined (with the exception of Miyazaki in 1890), while the share of manufacturing industry expanded.

In fact, the years from 1874 to 1890 are when industrialization in Japan gathered considerable steam—despite, or maybe because, of considerable economic and political upheaval during this period. During the latter half of the 1870s, Japan experienced severe inflation as a result of the issuance of notes to raise funds for the government's industrial development policy and to cover the war expenditure to quell the 1877 Satsuma Rebellion. However, from the early 1880s, the government embarked on deflationary policies under finance minister Masayoshi Matsukata. While these brought ruin to many small and

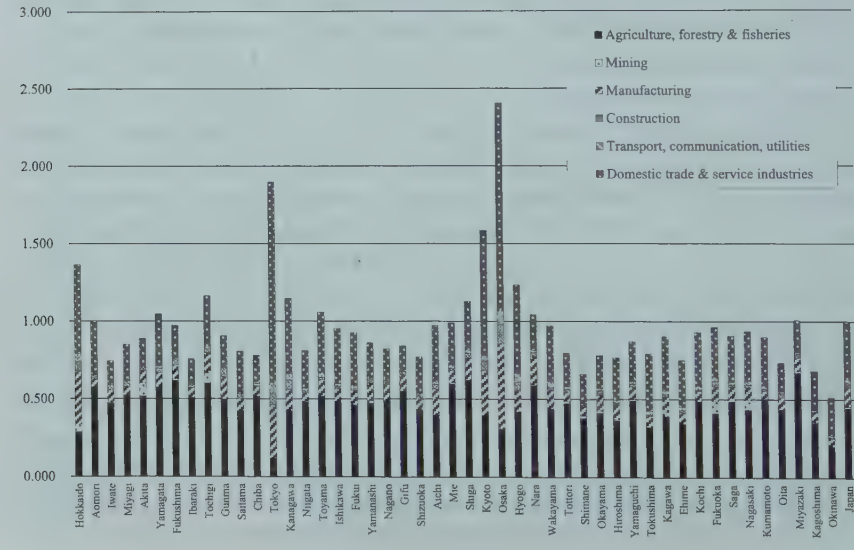
[8] The correlation coefficients are 0.53 for 1874, 0.60 for 1890, 0.74 for 1909, 0.67 for 1925, 0.34 for 1935, and 0.12 for 1940, indicating that the correlation first increased before gradually becoming smaller over time.

Figure 3.1 Per capita value added and industrial structure (based on local prices, Japan = 1)

(a) 1874



(b) 1890



(c) 1909

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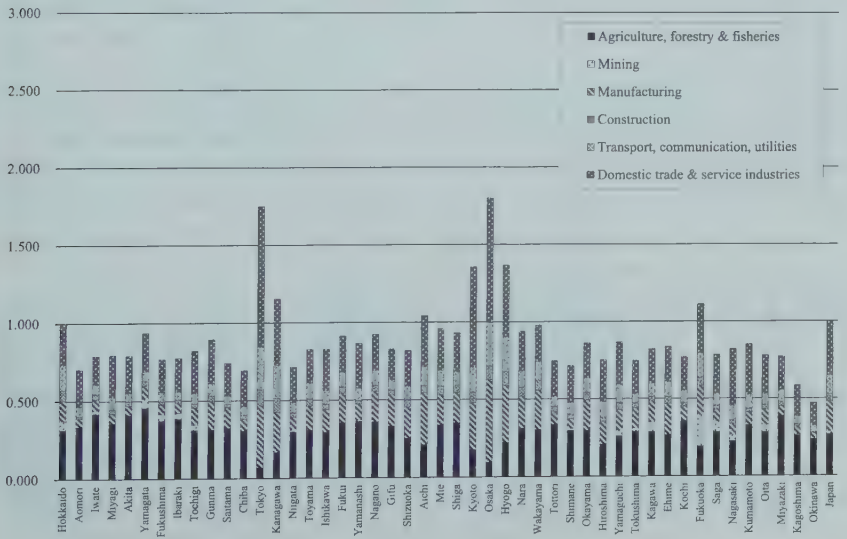
(d) 1925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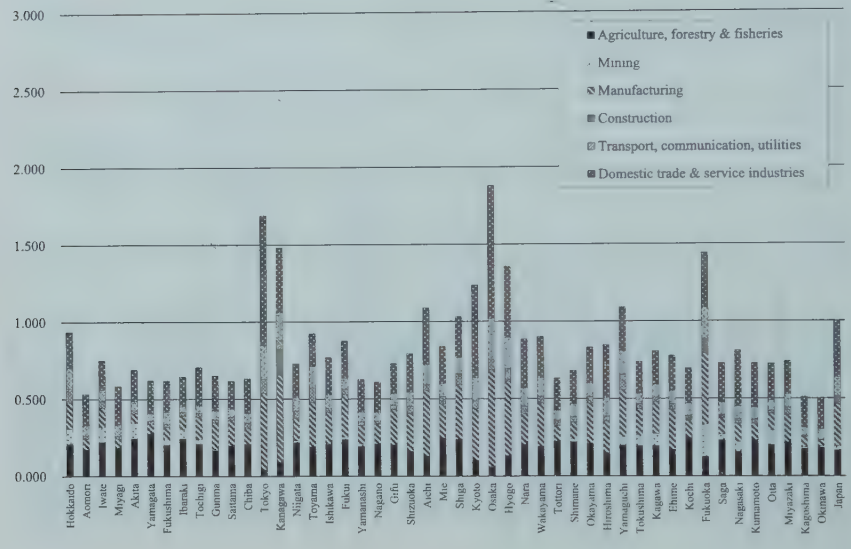
(e) 1935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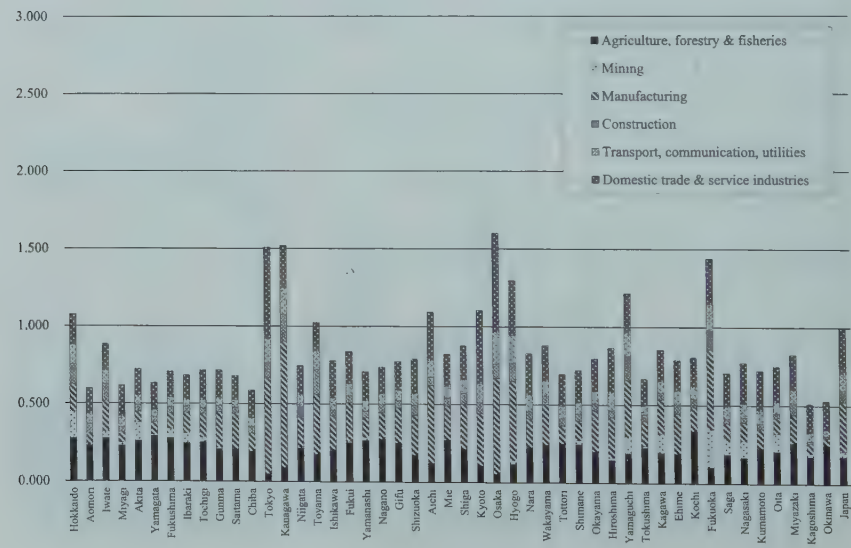
(f) 1940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medium-scale farmers, leading to a growing concentration of farmland among large owners, they also created a pool of wage laborers to provide the necessary workforce for industrialization. The deflationary policies bore fruit in the mid-1880s and Japan started to embark on full-fledged industrialization. In the next subsection, we will consider how this industrialization process affected prefectural income inequality.[9]

3.3.2 Trends in prefecture-level manufacturing output

As in other countries, manufacturing industry was the main engine of growth in the economic development of modern Japan. However, industrialization did not proceed at an even pace across Japan, with important implications for prefectural income inequality. A key aspect in this regard is the fact that manufacturing and agricultural products tend to be tradable. This means that prefectures can specialize in manufacturing activities, which tend to be characterized by a higher gross value added per worker (for instance, as shown in Table 3.1(c), by 1909, labor productivity in manufacturing and construction was more than 70% higher than in agriculture and forestry), export manufacturing products and import agriculture products, and thereby raise the gross value added per capita. On the other hand, because the products and services of the construction and tertiary sectors tend to be non-tradable, it is relatively difficult for a prefecture to specialize in high value added activities in these sectors. Therefore, prefectures with a larger manufacturing sector share are likely to be better off, and the uneven spread of modern manufacturing activities at the start of modern economic development is likely to give rise to increasing spatial inequality.

Based on these considerations, let us start by comparing the manufacturing sector per capita gross value added expressed in national average prices across prefectures for each benchmark year. This is done in the various panels of Figure 3.2, where the vertical axis shows prefectures' per capita manufacturing gross value added relative to the average for Japan as a whole (i.e., Japan average = 1) as well as a

[9] Figures of prefectures' GPP by industry for the post-war period are not shown to conserve space, but are available from the authors on request.

breakdown into the various manufacturing sector industries. It should be noted that data for 1874 for Okinawa and Hokkaido are not available, since these regions had not been established as prefectures at the time.[10]

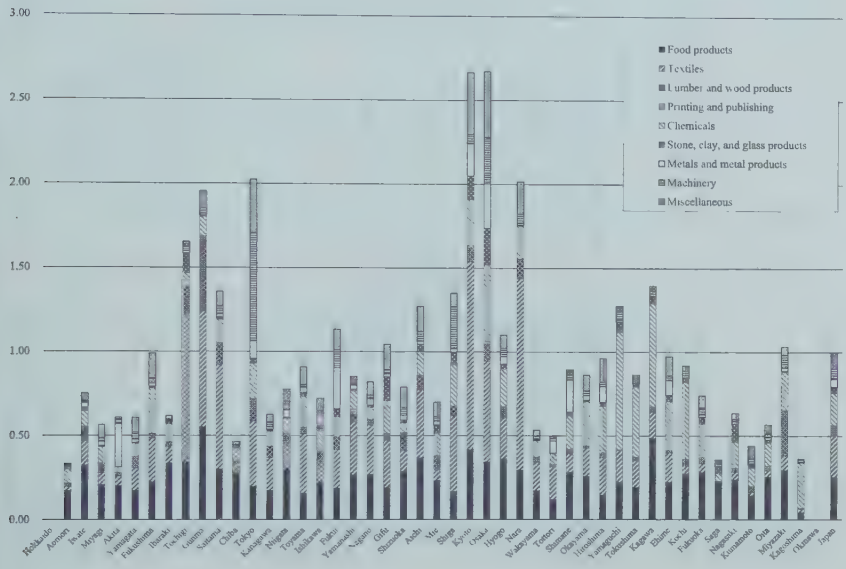
Starting with 1874, we find that manufacturing industry largely centered on prefectures that had already been the core regions of handicraft industry production during the Edo period, such as Kyoto, Osaka, and Nara. Other major manufacturing regions include Gunma, Tochigi, and Saitama, which had relatively large food and textile industries. Comparing the most industrialized with the least industrialized prefectures, manufacturing per capita gross value added in Osaka and Kyoto was 8.0 times that in Aomori, 7.5 times that in Saga, and 7.3 times that in Kagoshima. In the period that followed—the 1870s and 1880s—the Meiji government implemented its so-called industrial development policy, as part of which it pursued the introduction of foreign technology in areas such as railroads, mining, iron manufacturing, shipbuilding, silk reeling, and cotton spinning. In addition, the government built large-scale model factories, choosing locations in which a particular industry had flourished since the Edo period. (Examples include the 2,000-spindle cotton spinning plants built in major areas of cotton production in various prefectures; the Kamaishi Iron Works in Iwate prefecture, where foot-bellow iron mills had been used since the Edo period; and the Tomioka Silk Filature in Gunma prefecture known for its sericulture and silk reeling.) However, while these government factories did play some part in the diffusion of technology, production did not always run smoothly and commercially they were often a failure.[11] Therefore, although there are some examples where government factories became viable after they were sold off, such as the Kamaishi Iron Works, the government's industrial development

[10] As explained in Appendix 2, for 1874, we estimated manufacturing gross value added for Hokkaido and Okinawa using information on labor productivity in constant prices for prefectures nearby. This means that we cannot divide manufacturing gross value added into the manufacturing subsectors. For this reason, Hokkaido and Okinawa are included in the panel for 1874 in Figure 3.1 but are omitted in the panel for 1874 in Figure 3.2.

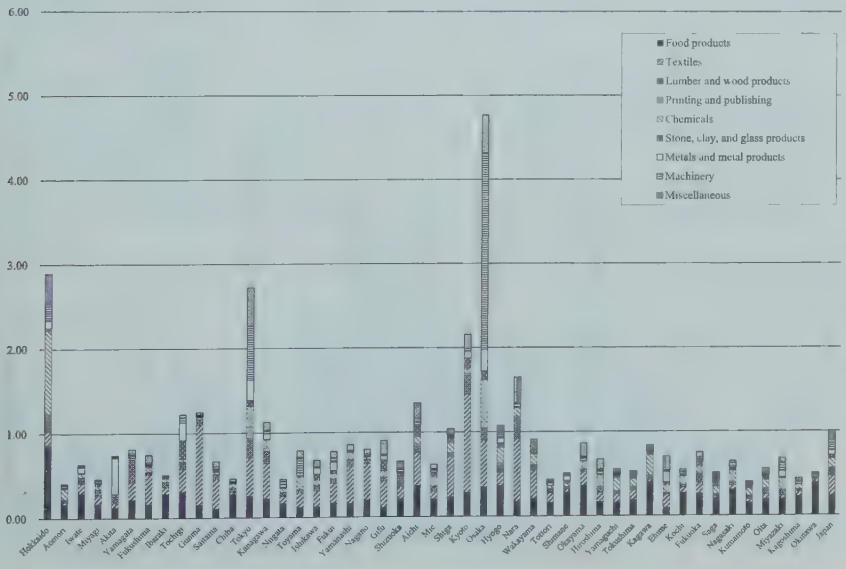
[11] For more details on the introduction of Western technology in modern Japan, see Morris-Suzuki (1994).

Figure 3.2 Manufacturing per capita value added by prefecture (in national average prices, Japan = 1)

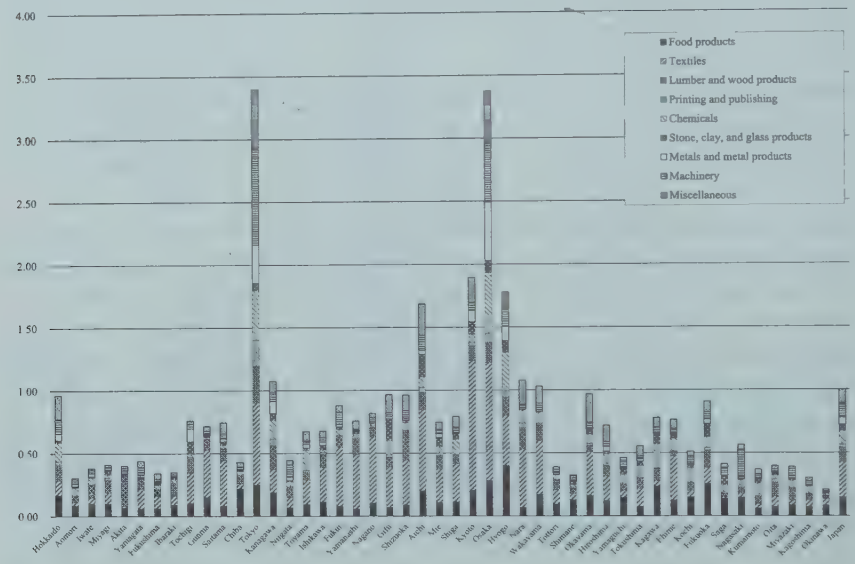
(a) 1874



(b) 1890



(c) 1909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Printing and publishing
Chemicals
Stone, clay, and glass products
Metals and metal products
Machinery
Miscellaneous
Hokkaido
Aomori
Iwate
Miyagi
Akita
Yamagata
Fukushima
Ibaraki
Tochigi
Gunma
Saitama
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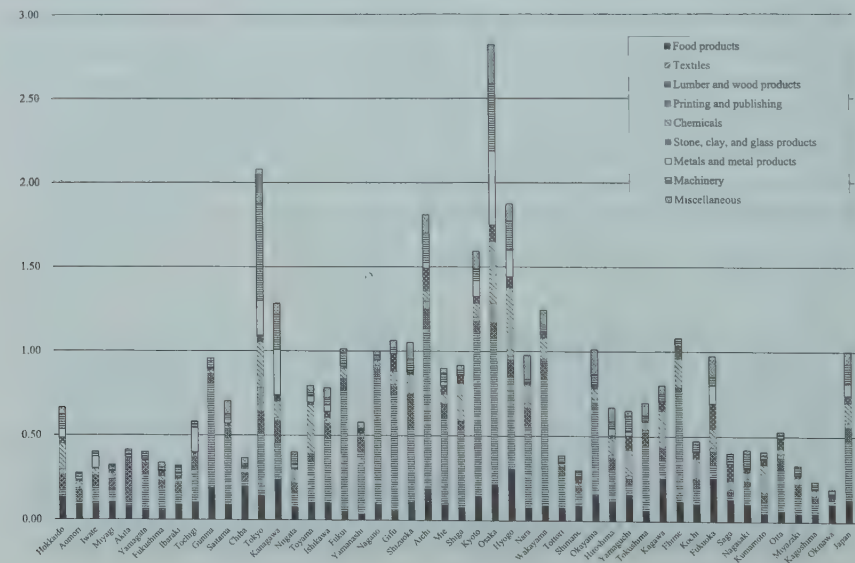
Japan

(d) 1925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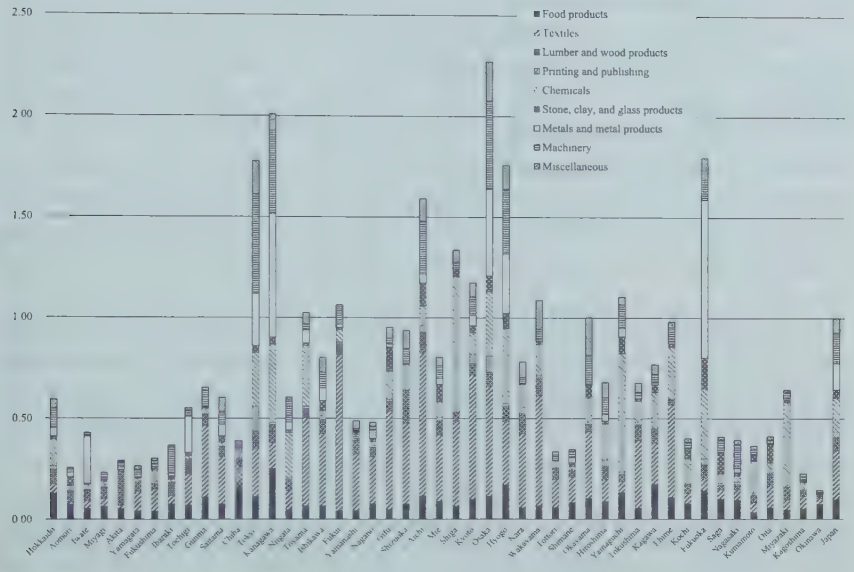
(e) 1935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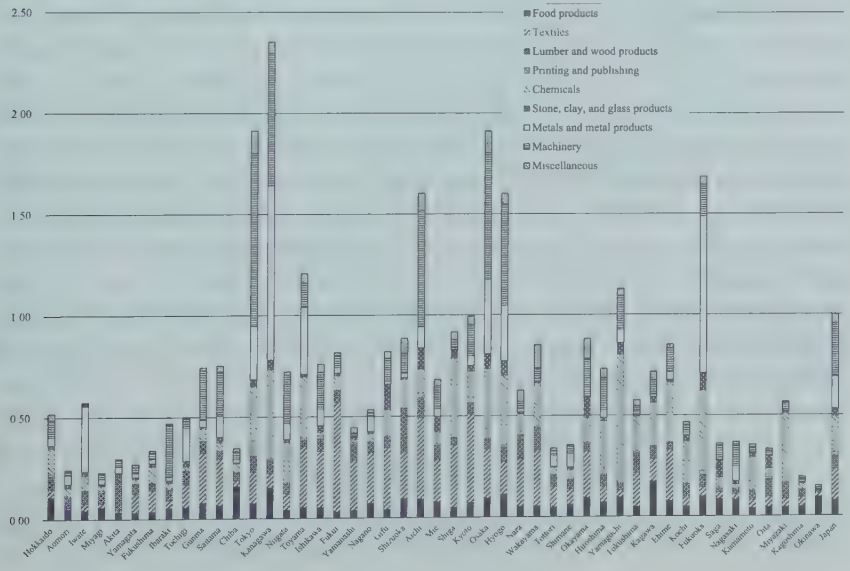
(f) 1940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policy seems to have played only a limited role in Japan's industrialization and there is little in Figure 3.2 to suggest that it had any impact on developments in prefectural inequality at the time.

Next, looking at the panel for 1890 shows that Osaka—which had become the center of the spinning industry, of which the Osaka Cotton Spinning Company (established in 1882) is the most famous example, and of machinery production such as arms and ships—took the top position. Other leading prefectures were Hokkaido, which produced foodstuffs and chemical goods, Kyoto, which saw an expansion of its textile industry, and Tokyo. Osaka's manufacturing per capita gross value added was 11.8 times that of Kumamoto and 11.7 times of that of Aomori.

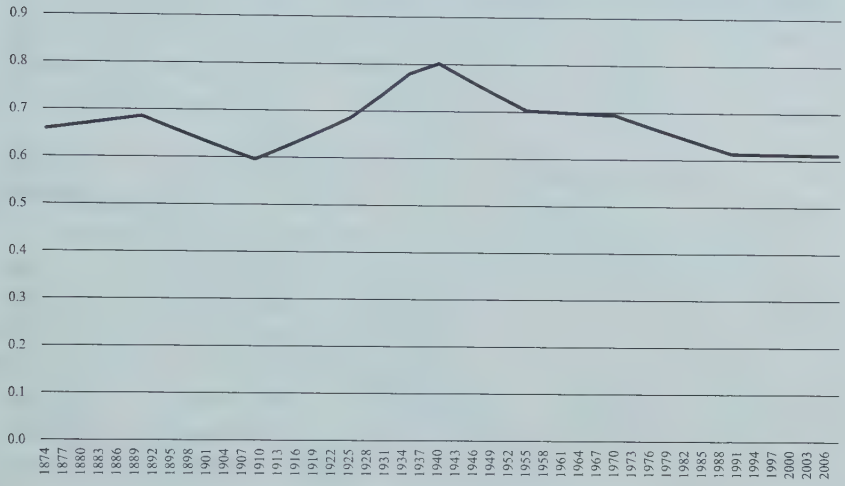
By 1909, Tokyo had become a major manufacturing center alongside Osaka. Tokyo's manufacturing per capita gross value added was 16.3 times that of Okinawa and 11.2 times that of Aomori, indicating that the gap between the top and bottom prefectures in terms of per capita manufacturing gross value added had grown even further. Next, the figure for 1925 shows a growing agglomeration of manufacturing industry around the main manufacturing centers of Osaka and Tokyo, with neighboring prefectures such as Hyogo and Kanagawa showing substantial increases and Aichi emerging as another manufacturing center. In addition, industrialization, concentrating on textiles, had started spreading to the northern inland Kanto region (the region north of Tokyo), the Tokai region south-west of Tokyo on the Pacific coast, and Hokuriku, the region north-west of Tokyo on the Japan Sea side of Japan. Finally, by 1935 and 1940, with the importance of the textile industry beginning to wane and the heavy and chemical industries having gained a prominent role, the concentration of industry shifted again, with Kanagawa and Fukuoka becoming major manufacturing centers.

Finally, let us examine the pattern of industrialization in terms of Krugman's (1991a) index of regional specialization. The index of regional specialization is defined as

$$S=\frac{1}{R(R-1)}\sum_{r=1}^{R}\sum_{r'=1}^{R-1}SI_{r,r'}$$

where

Figure 3.3 Index of regional specialization (based on gross value added in local prices)



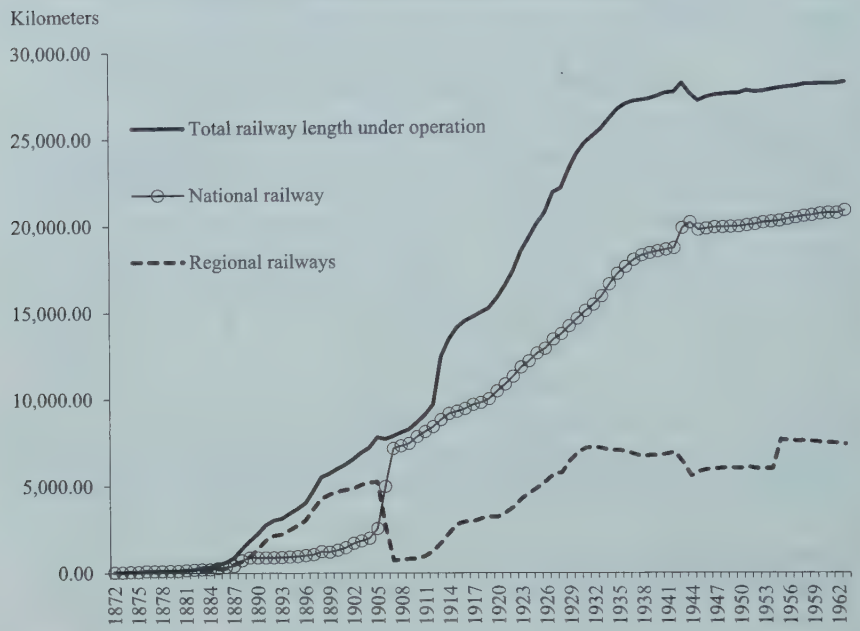
$$SI_{r,r'} = \sum_{i=1}^{I} \left| \frac{Y_{i,r}}{Y_r} - \frac{Y_{i,r'}}{Y_{r'}} \right|$$

and $Y_{i,r}$ is the gross value added (in local prices) in prefecture r's industry i and Y_i is the gross value added (in local prices) for all manufacturing industries in prefecture r. Moreover, R is the number of prefectures and I is the number of industries. If S is 0, this means that the industry composition of the manufacturing sector in prefectures r and r' is completely identical. On the other hand, if S is 2, this indicates specialization where the industry composition in the two prefectures is completely different.

The results are shown in Figure 3.3 and indicate that regional specialization increased from 1909 to 1940, but industries became more evenly distributed after World War II. The increase in specialization after 1909 may, as in the case of the United States (see Kim, 1995), be related to the development of the railroad system. Japan's railroad network, as shown in Figure 3.4, rapidly expanded during the period from 1910 to 1930 (for details, see Minami, 1965).

In this context, it is interesting to note that the development of the railroad network is closely linked to political developments during this period. In 1900, domain factions and the political parties, which

Figure 3.4 Expansion of Japan's rail network



Source: Minami (1965).

had hitherto opposed each other, joined forces when Hirobumi Ito, a four-time prime minister and leading figures of the domain factions, formed the *Rikken Seiyukai* [*Friends of Constitutional Government*] party. The *Rikken Seiyukai*, similar to the Liberal Democratic Party in the post-war era, stood for large public spending and sought to build and extend railroads in rural areas in order to gain rural votes (mainly landlords). Together with the domain factions (who controlled many bureaucratic posts), the *Rikken Seiyukai* remained in power until the arrival of the two-party system with the Constitutional Democratic Party (the former Constitutional Party) in the 1920s and continued to press ahead with patronage-driven politics favoring rural areas.[12] Although this brief description only scratches the surface and it is beyond the scope of this study to examine to

[12] For more details on the political history of modern Japan, see, e.g., Banno (1992, 2014).

what extent government policies during this period affected prefectural inequality, it clearly illustrates that in order to understand developments in prefectural inequality and the distribution of industries across Japan during this (or any other) period political aspects need to be taken into account.

3.4 Decomposition of prefectural income inequality

Having looked at developments in Japan's industrial structure both at the national and the prefectural level, we next examine the role that prefectural differences in industrial structure have played in shaping prefectural income inequality, which is the main focus of this study. To do so, we decompose differences in prefectural income into the contribution of differences in the share of the gainfully occupied population, differences in industrial structure, and differences in labor productivity within the same industry.

Denoting the average of the wealthiest group of prefectures (the top 20% in terms of cumulative population) by subscript T and the average for Japan as a whole by subscript J, we can decompose the logarithm of the ratio of the per capita GPP of the wealthiest group of prefectures, y_T, to the average per capita GPP for Japan as a whole, y_J, as follows:[13]

$$\ln\left(\frac{y_T}{y_J}\right) = \ln\left(\frac{\frac{L_T}{N_T}}{\frac{L_J}{N_J}}\right) + \ln\left(\frac{\sum_{i=1}^{I} v_{i,J}^{L} y_{i,T}}{\sum_{i-1}^{I} v_{i,J}^{L} y_{i,J}}\right)$$

$$= \ln\left(\frac{\frac{L_T}{N_T}}{\frac{L_J}{N_J}}\right) + \ln\left(1 + \frac{\sum_{i=1}^{I} \frac{1}{2}(y_{i,T}+y_{i,J})(v_{i,T}^{L}-v_{i,J}^{L})}{\sum_{i=1}^{I} v_{i,J}^{L} y_{i,J}}\right)$$

[13] We also examined the top and bottom 10% and top and bottom 50% of prefectures, and found that the results were very similar.

$$+\frac{\sum_{i=1}^{I}\frac{1}{2}(v_{i,J}^{L}+v_{i,T}^{L})(y_{i,T}-y_{i,J})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\Bigg)$$

$$=\ln\left(\frac{\frac{L_T}{N_T}}{\frac{L_J}{N_J}}\right)+\ln\left(1+\frac{\sum_{i=1}^{I}\frac{1}{2}(y_{i,T}+y_{i,J})(v_{i,T}^{L}-v_{i,J}^{L})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\right)$$

$$+\ln\left(1+\frac{\sum_{i=1}^{I}\frac{1}{2}(v_{i,J}^{L}+v_{i,T}^{L})(y_{i,T}-y_{i,J})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\right)$$

$$+\varepsilon_{T,J}.$$

In the above equation, N_T and L_T stand for the population and the gainfully occupied population of prefecture group T, $v_{i,T}^{L}$ is the share of those occupied in industry i in the total gainfully occupied population in prefecture group T, and $y_{i,T}$ represents labor productivity in industry i in prefecture group T (where labor productivity is gross valued added in national average prices divided by the gainfully occupied population). All variables with subscript J represent the average for Japan as a whole. $\varepsilon_{T,J}$ is the residual as a result of approximation.

Denoting the average of the poorest group of prefectures (the bottom 20% in terms of cumulative population) by subscript B, we can similarly decompose the logarithm of y_B/y_J using the same equation above. Consequently, we can decompose the logarithm of the ratio of the average per capita GPP of the wealthiest prefectures and of the poorest prefectures, y_T/y_B, as follows:

(1) Differences in the share of the gainfully occupied population

$$\ln\left(\frac{\frac{L_T}{N_T}}{\frac{L_B}{N_B}}\right)$$

(2) Differences in labor productivity due to differences in industrial structure

$$\ln\left(1+\frac{\sum_{i=1}^{I}\frac{1}{2}(y_{i,T}+y_{i,J})(v_{i,T}^{L}-v_{i,J}^{L})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\right)$$

$$-\ln\left(1+\frac{\sum_{i=1}^{I}\frac{1}{2}(y_{i,B}+y_{i,J})(v_{i,B}^{L}-v_{i,J}^{L})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\right)$$

(3) Differences in labor productivity due to within-industry differences in labor productivity

$$\ln\left(1+\frac{\sum_{i=1}^{I}\frac{1}{2}(v_{i,J}^{L}+v_{i,T}^{L})(y_{i,T}-y_{i,J})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\right)$$

$$-\ln\left(1+\frac{\sum_{i=1}^{I}\frac{1}{2}(v_{i,J}^{L}+v_{i,B}^{L})(y_{i,B}-y_{i,J})}{\sum_{i=1}^{I}v_{i,J}^{L}y_{i,J}}\right)$$

(4) Residual

$$\varepsilon_{T,J}-\varepsilon_{B,J}$$

For illustration, let us consider a simple example. Consider a country consisting of two prefectures, prefecture A and prefecture B, and

two industries, industry X and industry Y. Labor productivity in industry X is assumed to be higher than in industry Y. Given this setting, let us examine under which circumstance per capita value added in prefecture A will be higher than in prefecture B.

First, if industries X and Y account for the same share of employment in both prefectures and labor productivity in industry X is the same in both prefectures and in industry Y also the same in both prefectures, then prefecture A will have higher per capita gross value added than prefecture B if the occupied population share in prefecture A is higher than in prefecture B (represented by term (1) above). Second, assuming alternatively that the occupied population share and labor productivity in industries X and Y are the same in both prefectures, per capita value added in prefecture A will be higher if industry X (where labor productivity is higher than in industry Y) accounts for a larger share of employment in prefecture A than in prefecture B (represented by term (2) above). Third and finally, assuming that the occupied population shares and the employment shares of industries X and Y are the same in the two prefectures, per capita gross value added in prefecture A will be higher if labor productivity in one or both of the industries—for example due to the use of new technology—is higher than in prefecture B (represented by term (3) above).

We decompose prefectural inequality for all benchmark years classifying industries into the following three groups: (1) agriculture, forestry, and fisheries; (2) mining, manufacturing, and construction; and (3) domestic commerce and services; transport, communication, and public utilities. In addition, except for 1874, for which necessary data are not available, we conduct the same decomposition splitting the last group into (a) commerce and services and (b) transport, communication, and public utilities.

Before presenting the decomposition results, let us briefly look at the data on which the decomposition is based, namely the share of the gainfully occupied population in the total population, labor productivity by industry, and employment shares by industry. These are presented in Table 3.2 for the top and bottom 20% of prefectures and Japan as a whole. Labor productivity and employment shares are expressed relative to the national average for agriculture, forestry, and fisheries (i.e., Japan average in agriculture, forestry, and fisheries = 1). In the table,

Table 3.2 Gainfully occupied population share, labor productivity, and employment by sector in the top and bottom 20% of prefectures

(a) Share of gainfully occupied population and labor productivity

	1874				1890				1909			
	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B
Share of occupied persons in population	59.53%	63.64%	62.41%		52.85%	59.94%	58.34%		42.45%	49.91%	47.60%	
Agriculture, forestry, and fisheries	1.30	0.78	1.00	1.66	1.13	0.82	1.00	1.38	1.20	0.86	1.00	1.39
Mining, manufacturing, construction	1.59	0.84	1.04	1.88	2.12	0.67	1.05	3.18	3.20	1.03	1.81	3.10
Services	3.22	1.60	2.26	2.01	4.47	1.87	2.78	2.39	4.74	2.28	3.19	2.07
Domestic trade and services	-	-	-	-	4.91	2.02	3.02	2.43	4.61	2.27	3.12	2.04
Transport, communication, utilities	--	--	-	-	1.87	0.84	1.22	2.23	5.46	2.41	3.63	2.26

	1925				1935				1940			
	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B
Share of occupied persons in population	42.40%	48.04%	45.37%		42.44%	48.25%	45.48%		43.21%	47.62%	46.30%	
Agriculture, forestry, and fisheries	1.20	0.84	1.00	1.44	1.35	0.87	1.00	1.56	1.56	0.89	1.00	1.74
Mining, manufacturing, construction	3.01	0.97	1.89	3.12	5.40	1.63	3.70	3.31	4.41	2.04	3.47	2.16
Services	3.62	2.28	2.88	1.59	4.79	2.91	3.90	1.65	3.69	2.31	2.99	1.60
Domestic trade and services	3.15	2.04	2.51	1.54	4.05	2.52	3.29	1.61	3.19	1.99	2.53	1.60
Transport, communication, utilities	6.44	3.82	5.03	1.69	10.91	6.23	8.71	1.75	7.24	4.50	5.91	1.61

	1955				1970				1990				2008			
	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B
Share of occupied persons in population	45.69%	46.10%	45.66%		55.03%	51.37%	52.31%		64.09%	46.71%	51.99%		58.40%	44.10%	50.28%	
Agriculture, forestry, and fisheries	1.17	0.85	1.00	1.38	1.31	0.94	1.00	1.39	0.88	0.98	1.00	0.89	0.87	1.02	1.00	0.85
Mining, manufacturing, construction	4.19	2.67	3.66	1.57	5.45	3.39	4.66	1.61	4.50	3.68	4.47	1.22	4.36	3.77	4.13	1.16
Services	3.15	2.11	2.67	1.49	3.78	2.66	3.25	1.42	4.13	2.96	3.44	1.40	4.05	2.84	3.33	1.42
Domestic trade and services	3.07	1.95	2.50	1.57	3.65	2.56	3.09	1.43	4.14	2.87	3.37	1.44	4.00	2.74	3.24	1.46
Transport, communication, utilities	3.65	3.31	3.74	1.10	4.70	3.43	4.39	1.37	4.09	3.82	4.08	1.07	4.60	3.90	4.32	1.18

(b) Number of gainfully occupied persons by sector

	1874				1890				1909			
	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B
Agriculture, forestry, and fisheries	0.90	1.08	1.00	0.83	0.80	1.10	1.00	0.73	0.61	1.18	1.00	0.52
Mining, manufacturing, construction	0.20	0.14	0.18	1.49	0.41	0.31	0.35	1.31	0.50	0.29	0.38	1.73
Services	0.31	0.19	0.23	1.57	0.46	0.26	0.32	1.78	0.67	0.32	0.40	2.11
Domestic trade and services	—	—	—	—	0.40	0.23	0.28	1.75	0.57	0.28	0.35	2.06
Transport, communication, utilities	—	—	—	—	0.07	0.03	0.04	2.02	0.10	0.04	0.06	2.49

	1925				1935				1940			
	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B
Agriculture, forestry, and fisheries	0.41	1.26	1.00	0.33	0.32	1.35	1.00	0.24	0.24	1.41	1.00	0.17
Mining, manufacturing, construction	0.66	0.43	0.52	1.54	0.74	0.46	0.58	1.59	1.03	0.49	0.70	2.12
Services	1.07	0.45	0.62	2.37	1.28	0.52	0.76	2.45	1.19	0.57	0.76	2.10
Domestic trade and services	0.92	0.39	0.53	2.34	1.14	0.47	0.67	2.44	1.04	0.50	0.66	2.11
Transport, communication, utilities	0.15	0.06	0.09	2.55	0.14	0.05	0.09	2.52	0.15	0.07	0.10	2.08

	1955				1970				1990				2008			
	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B	(A) Top 20% average	(B) Bottom 20% average	Japan average	A/B
Agriculture, forestry, and fisheries	0.27	1.42	1.00	0.19	0.10	1.86	1.00	0.05	0.17	1.87	1.00	0.09	0.30	1.51	1.00	0.20
Mining, manufacturing, construction	0.98	0.37	0.60	2.65	2.14	1.16	1.76	1.85	3.77	3.43	3.81	1.10	5.05	4.80	5.21	1.05
Services	1.18	0.63	0.81	1.87	2.80	2.02	2.28	1.38	7.44	6.07	6.56	1.23	14.61	13.65	13.75	1.07
Domestic trade and services	1.02	0.55	0.71	1.85	2.46	1.79	1.99	1.38	6.71	5.51	5.91	1.22	13.37	12.46	12.59	1.07
Transport, communication, utilities	0.15	0.07	0.11	2.04	0.34	0.24	0.28	1.45	0.73	0.56	0.65	1.30	1.24	1.19	1.15	1.04

"Services" stands for domestic trade and services, and transport, communication, and public utilities.

Starting with Table 3.2(a), we find that the gainfully occupied population share in the pre-war period tended to be higher in the poorer than the wealthier prefectures. This likely reflects what is known as the "first Douglas-Arisawa law" (Douglas, 1934; Arisawa, 1956), namely that the lower the income level of household heads, the more likely it is that wives and other family members will be working.[14] Interestingly, the pattern reverses in the post-war period, with the occupied population share becoming higher in wealthier than in poorer prefectures. As will be discussed in greater detail in Chapter 4, this reversal reflects the migration of mainly younger workers from poorer rural to wealthier urban prefectures and the resultant impact on prefectural demographic structures.

Next, comparing labor productivity across sectors for Japan as a whole we find—in line with the results discussed earlier—that whereas labor productivity differences between agriculture, forestry, and fisheries on the one hand and mining, manufacturing, and construction as well as transport and communication on the other tended to increase, those between agriculture, forestry, and fisheries on the one hand and domestic trade and services on the other remained relatively stable. This reflects the fact that labor productivity in mining, manufacturing, and construction as well as transport and communication tended to grow faster as a result of capital accumulation and technological improvements than in domestic trade and services.

Next, comparing labor productivity between the wealthiest and poorest prefectures, we find that in the pre-war period labor productivity in agriculture, forestry, and fisheries in the wealthiest prefectures was about 1.5 times as high as in the poorest prefectures, while in the other industries it was about two to three times as high. What we are particularly interested in, however, is how these productivity differences within sectors developed over time, since these are an important determinant of developments in prefectural income inequality. In the previous chapter, we saw that in the initial stage of Japan's

[14] This implies that the employment ratio among women should be higher in poorer prefectures. Unfortunately, at present we do not have data that would allow us to examine this hypothesis.

modern economic development—that is, between 1874 and 1890—prefectural inequality increased. Table 3.2(a) allows to examine which sectors contributed to this increase. Specifically, we find that whereas in 1874, labor productivity in the top 20% of prefectures in agriculture, forestry, and fisheries was 1.66 times as high as that in the bottom 20%, by 1890 the difference had shrunk to a factor of 1.38. On the other hand, the gap in both manufacturing, mining, and construction as well as services increased considerably, from a factor of 1.88 and 2.01 to a factor of 3.18 and 2.39, respectively. This result suggests that the increase in productivity differences in manufacturing played a large part in the increase in prefectural inequality during this period.

Looking at developments in productivity differences over the rest of the period, we find that in agriculture, forestry, and fisheries the relative gap—after the initial drop between 1874 and 1890—increased slightly in the pre-war period and then decreased in the post-war period. On the other hand, in the manufacturing sector, the gap—after the initial jump between 1874 and 1890—remained more or less unchanged (at a factor of about 3.1 to 3.3) until 1935, before steadily decreasing between 1940 and 2008. Meanwhile, in services, the relative gap declines more or less steadily from the peak in 1890, falling to a factor of 1.60 in 1940 and declining further in the post-war period.[15] Finally, looking at the two service sector categories separately, the relative gaps in labor productivity in domestic trade and services as well as transport, communication, and public utilities during the pre-war period closely mirror that in services overall (for instance, the top prefectures lead by a factor of about 2.2 to 2.4 in 1890, and this shrinks to a factor of 1.6 in 1940). The figures in Table 3.2(a) thus indicate that each of the sectors followed its own pattern in terms of productivity divergence and convergence.

Turning to Table 3.2(b), this shows differences in employment structures between the top and bottom 20% of prefectures. The table

[15] Trends in relatively labor productivity gaps are somewhat different when comparing the top and bottom 10% of prefectures. Specifically, the gap in mining, manufacturing, and construction, following a large jump between 1874 and 1890, declines until 1909 before increasing again through 1935. On the other hand, in agriculture, forestry, and fisheries, labor productivity differences increased notably from 1890 to 1940.

indicates that in poorer prefectures proportionately more persons were employed in agriculture, forestry, and fisheries than in wealthier prefectures. Moreover, while this pattern can already be observed at the start of our observation period in 1874, it became more and more pronounced over time (up until 1970).[16] Conversely, proportionately fewer persons were employed in manufacturing and services in poorer prefectures than in wealthier prefectures, and this pattern holds throughout the observation period. Thus, even before looking at the decomposition results, we already get a sense of why poorer prefectures were poorer: they had a larger share of the workforce employed in agriculture, which, as seen in Table 3.2(a), is characterized by lower productivity than manufacturing and services.

Table 3.2(b) also shows that developments in differences in employment structures differ considerably across sectors. Whereas differences in the agricultural employment share steadily increase over time, those in the manufacturing employment share show no clear trend until they jump in 1940, peak in 1955, and then gradually decline until, by 2008, the manufacturing employment share is almost identical in the wealthiest and poorest prefectures. Finally, differences in the service sector employment share gradually increase until 1935 before then gradually decreasing again. Interestingly, as seen in the last column of the table, by 2008, the only major difference in employment structures between the wealthiest and poorest prefectures is the share employed in agriculture, which is about five times higher in the poorer prefectures.

Let us take a closer look at developments during the early phase of industrialization, which we are particularly interested in in this chapter. Table 3.2(b) suggests that between 1874 and 1890, the employment share of the manufacturing sector increased in both the leading and the lagging prefectures, and although the gap between the two increased somewhat, this increase is not particularly pronounced. In other words, industrialization spread relatively evenly across Japan. This can be seen more clearly in Figure 3.5, which shows the coeffi-

[16] The convergence in agricultural employment structures after 1970 reflects the fact that while agricultural employment in the top 20% of prefectures was already so low that it did not decline any further, it continued to fall in Japan as a whole, including in the bottom 20% of prefectures.

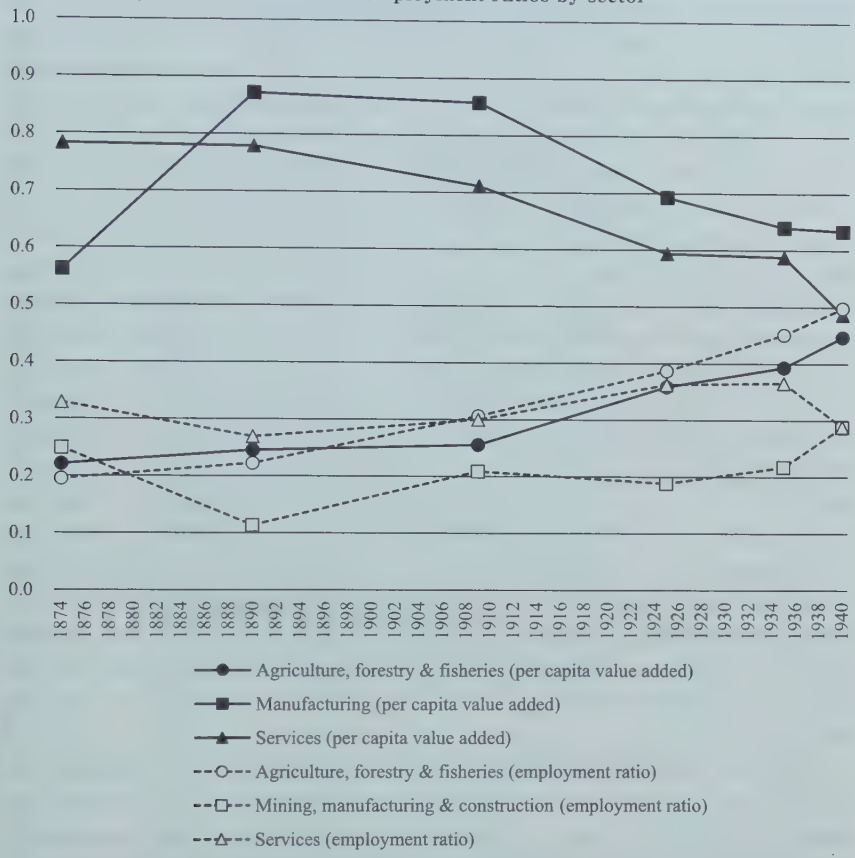
cients of variation (CVs) for agriculture, manufacturing, and service sector population-weighted employment shares and per capita value added. The figure shows that between 1874 and 1890, the CV for manufacturing employment shares actually decreased, thus confirming that in this sense industrialization spread relatively evenly. This, in turn, is consistent with the notion that rural industry—based on the foundations laid by proto-industrialization during the Edo period—played a key role in Japan's early industrialization process (see Appendix 1 and Saito, 1983, for more details). The figure also shows, however, that inequality in manufacturing per capita value added rose sharply between 1874 and 1890, meaning that prefectural differences in labor productivity increased substantially (as already seen in Table 3.2(a)). This implies that some prefectures specialized in manufacturing activities with high labor productivity, while others specialized in activities with lower labor productivity. Although data to examine this conjecture further unfortunately are unavailable,[17] it is in line with the increase in regional specialization shown in Figure 3.3, and it is not difficult to find concrete examples to illustrate this contrast, such as the Osaka Cotton Spinning Company on the one hand and small-scale silk-reeling in Gunma prefecture on the other.

Figure 3.5 further shows that no such increase in the CV of per capita value added in the service sector can be observed, which is in line with the finding in Table 3.2(a) that the increase in labor productivity differences between the top and bottom 20% of prefectures was much less pronounced than in the manufacturing sector. The figure thus confirms that it was the manufacturing sector that was mainly responsible for the increase in regional income inequality during the period 1874–1890.

Next, let us turn to developments from 1890 to 1909. This period is the time when the first enterprise boom occurred and full-fledged industrialization concentrating on light industry made headway. As seen in Chapter 2 (Figure 2.1), prefectural income inequality continued to increase during this period, but the increase was far more moderate than that in the preceding period from 1874 to 1890. The reason is that, as seen in Table 3.2(a), labor productivity differences in manu-

[17] Specifically, we would need estimates of the gainfully occupied population in each manufacturing industry, which are currently not available.

Figure 3.5 Population-weighted coefficients of variation of prefectural per capita gross value added and employment ratios by sector


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1874 1876 1878 1880 1882 1884 1886 1888 1890 1892 1894 1896 1898 1900 1902 1904 1906 1908 1910 1912 1914 1916 1918 1920 1922 1924 1926 1928 1930 1932 1934 1936 1938 1940
Agriculture, forestry & fisheries (per capita value added)
Manufacturing (per capita value added)
Services (per capita value added)
Agriculture, forestry & fisheries (employment ratio)
Mining, manufacturing & construction (employment ratio)
Services (employment ratio)

Note: Employment ratios are calculated as the ratio of the gainfully occupied population in a particular sector to the prefectural population overall.

facturing, mining, and construction essentially remained unchanged between 1890 and 1909 and decreased in services, which is mirrored by the CV in per capita value added in manufacturing and services shown in Figure 3.5.

This finding is consistent with the argument by Nakamura and others that during the first enterprise boom rural industries played an important role. Specifically, Nakamura (2010) argues that the period from the mid-1880s, when industrialization started to take off, until

around 1905—that is, around the end of the Russo-Japanese War—can be considered as an era in which non-metropolitan regions, such as Fukuoka, Iwate, and the Sennan District in Osaka prefecture, were at the forefront of Japan's industrial revolution. Such industrial development in the regions was driven by wealthy individuals, local government officials, and politicians residing in these areas against the backdrop of a widely shared "regional industrialization ideology," which held that the development of Japan's regions would promote the economic development of Japan as a whole and was based on the fact that personal relationships in the regions lowered transaction costs and facilitated investment. However, as the cost of electricity in urban areas declined, industry subsequently started to increasingly concentrate in urban areas and industrialization in the regions lost steam.[18]

The active investment in Japan's regions as part of the "regional industrialization ideology" is likely to have prevented a more pronounced increase in prefectural income inequality after 1890. What is more, in this context it is important to note that this investment occurred not only in manufacturing, mining, and construction, but also in the service sector. Lastly, regarding the period between 1909 and 1925, we unfortunately at this point do not have sufficient data to examine Nakamura's argument that industry became increasingly concentrated in urban areas, but if this is the case, it would have worked in the direction of increasing prefectural income inequality during this period.

Having considered the underlying patterns and developments in the different components contributing to prefectural income inequality, let us finally turn to the decomposition results. Specifically, employing our estimates of per capita GPP on the basis of national average prices, we decompose the log of the ratio of the per capita GPP of the wealthiest prefectures to that of the poorest prefectures, y_T/y_B, into the four terms presented at the outset of this section. The results of the decomposition are presented in Table 3.3.

Starting with the difference in average per capita GPP between the wealthiest and poorest 20% of prefectures, we find that the devel-

[18] For more details, see Nakamura (2010) and, with regard to the investment behavior of wealthy individuals in the regions during this period, Tanimoto (1998).

Table 3.3 Decomposition of differences in per capita GPP

(Figures in italics show the percentage contribution of each factor to differences in per capita GPP)

	1874	1890	1909	1925	1935	1940	1955	1970	1990	2008
Difference in average per capita GPP (log)	0.602	0.753	0.834	0.810	1.072	0.863	0.823	0.774	0.706	0.612
	100	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
(1) Contribution of differences in the gainfully occupied population share	−0.067	−0.126	−0.162	−0.125	−0.128	−0.097	−0.009	0.069	0.316	0.281
	−11.10	*−16.71*	*−19.41*	*−15.41*	*−11.96*	*−11.26*	*−1.09*	*8.90*	*44.83*	*45.92*
(2) Contribution of differences in labor productivity due to differences in industrial structure	0.093	0.201	0.344	0.358	0.444	0.404	0.437	0.304	0.113	0.048
	15.53	*26.65*	*41.21*	*44.23*	*41.43*	*46.79*	*53.09*	*39.24*	*16.04*	*7.79*
(3) Contribution of differences in labor productivity within the same industry	0.587	0.719	0.716	0.611	0.681	0.567	0.390	0.383	0.272	0.284
	97.49	*95.53*	*85.88*	*75.45*	*63.49*	*65.61*	*47.38*	*49.48*	*38.52*	*46.42*
(4) Residual	−0.012	−0.041	−0.064	−0.035	0.075	−0.010	0.005	0.018	0.004	−0.001
	−1.92	*−5.46*	*−7.67*	*−4.28*	*7.03*	*−1.14*	*0.62*	*2.37*	*0.61*	*−0.13*

Notes:

1. Based on estimates in average national prices.
2. Based on the classification into three industry groups.

opment over time closely resembles the pattern for the coefficient of variation of per capita GPP shown in Chapter 2 (Figure 2.1). That is, prefectural income inequality rises from 1874 to 1890, falls in 1925, and then increases again, peaking in 1935, before generally declining after that. The most notable difference in fact can be observed for the post-war period, for which Table 3.3 suggests that regional inequality declined steadily and continuously, while Figure 2.1 suggests that it increased in the 1980s.

Next, looking at the contribution of differences in the gainfully occupied population share, we find that this has a negative sign throughout the pre-war period, before turning positive in 1970. This means that, during the pre-war period, a larger share of the population was gainfully occupied in the poorer than in the wealthier prefectures, and this helped to reduce the gap in per capita GPP. On the other hand, as seen earlier, the pattern reverses during the post-war period and especially from 1990 onward, the gainfully occupied population share becomes an important determinant of differences in per capita GPP differences, explaining more than 40%.

Turning to differences in labor productivity due to differences in industrial structure and within-industry productivity differences, the results suggest that both played a substantial role in prefectural income inequality. However, the size of the contribution of the two factors differs considerably over time and the trends they display provide some interesting clues with regard to the pattern of industrialization in Japan. Specifically, we find that in the early stages, up until around 1909, within-industry differences in labor productivity accounted for well over 80% of differences in per capita GPP. In absolute terms, the contribution of within-industry productivity differences increases between 1874 and 1890 (although it declines in percentage terms), but then declines more or less steadily over time. What this suggests is that in the early years, between 1874 and 1890, within-industry productivity differences across prefectures were extremely large and in fact increased as some prefectures introduced modern technology (from abroad) and/or were at the heart of infrastructure improvements, while others lagged behind. Over time, though, such differences diminished as technology and infrastructure dispersed across Japan.

On the other hand, the contribution of differences in industrial structure across prefectures displays an inverted U curve: in 1874,

they accounted for only 16% of per capita GPP differences, but this contribution rose to about 41–47% during the first half of the 20th century, peaked at 53% in 1955, and then gradually declined to only 8% in 2008. This pattern closely mirrors the development in the index of regional specialization shown in Figure 3.4 and indicates that prefectures' industrial structures were quite similar in the early stages before the onset of industrialization. However, as industrialization proceeded, regional specialization in specific industries increased, contributing to growing prefectural income inequality. Following World War II, regional specialization then gradually diminished, and the contribution of differences in industrial structure to differences in per capita GPP decreased.

Let us take a slightly more detailed look at developments in the early stages of Japan's modern economic development. The results indicate that between 1874 and 1890 both within-industry productivity differences and labor productivity differences due to differences in industrial structure increased. By far the most dominant factor, as mentioned, is differences in within-industry labor productivity, which is in line with the results shown in Table 3.2 and Figure 3.5, which indicated that during this period labor productivity differences especially in manufacturing, mining, and construction increased substantially, with the productivity advantage of the wealthiest prefectures over the poorest prefectures jumping from a factor of less than two to a factor of more than three. Ideally, we would like to disaggregate this sector further in order to examine whether these labor productivity differences are the result of differences in industrial structure within the manufacturing sector or the result of within-industry differences within the manufacturing sector. To do so, however, we would need estimates of the gainfully occupied population in each manufacturing industry, which at present are not available.

During the period from 1890 to 1909, prefectural income inequality also increased, but not to the same extent as in the preceding period. Differences in industrial structure make a larger contribution to inequality overall, while the contribution of within-industry productivity differences remains essentially unchanged (and shrinks on a percentage basis), which is in line with the results in Figure 3.2 showing that there was little change in productivity differences in each of the sectors between 1890 and 1909. This possibly reflects the active

investment in rural areas under the "regional industrialization ideology," which may have prevented labor productivity differences in both manufacturing and service industries from rising.

Prefectural income inequality declined slightly in the period from 1909 to 1925, driven mainly by a decline in within-industry productivity differences. Although within-industry productivity differences temporarily increased in 1935, they then declined again in 1940, falling to the same level as in 1874. Unfortunately, we are unable to examine why within-industry productivity differences declined, because we have been unable to estimate capital input and labor quality (educational attainment) at the prefectural level. However, likely reasons for this decline in within-industry productivity differences include increases in the capital-labor ratio, human capital accumulation, and TFP increases in lagging regions reflecting factors such as internal migration and the continuing diffusion of technology. In particular, capital-labor ratios are likely to have been substantially affected by the migration of labor from poorer to wealthier prefectures. This issue will be discussed in more detail in Chapter 4.

Finally, both productivity differences due to differences in industrial structure and within-industry productivity differences contributed to the increase in prefectural income inequality between 1925 and 1935. Regarding the increase in the contribution of differences in industrial structure, Table 3.2(b) suggests that changes in the employment structure between 1925 and 1935 actually were relatively small compared to changes in earlier periods. Thus, given that we measure labor productivity using gross value added per gainfully occupied person in terms of (national average) market prices, the increase in inequality as a result of differences in industrial structure likely reflects the substantial fall in the relative price of agricultural products during this period. Meanwhile, with regard to the contribution of within-industry productivity differences, Table 3.2(a) suggests that all three sectors saw an—albeit relatively minor—further increase in productivity differences, with differences in the manufacturing sector reaching their peak. Thus, the increase in prefectural income inequality likely was the result of substantial changes in relative prices between agricultural and industrial products as well as continuing regional specialization.

3.5 Conclusion

The aim of this chapter was to examine changes in prefectural income inequality and industrial structure during the pre-war period. The findings of the analysis can be summarized as follows. Prefectural income inequality, which increased in the early stages of Japan's modern economic development, was mainly due to within-industry differences in labor productivity. From 1874 to 1890 labor productivity differences in the manufacturing, mining, and construction sector increased considerably. Although further analyses are necessary to draw firmer conclusions, conjecturing from Figure 3.2, it appears that the rise of major industrial centers such as Osaka during this period played a key role. Nevertheless, it is important to note that industrialization was not confined to urban centers, but also took place in other (rural) regions, where increases in employment in the manufacturing sector kept pace with the leading areas (as seen in Figure 3.5). In this sense, it could be said that industrialization during this period was not regionally biased.

Moreover, regional inequality increased only moderately in the following period from 1890 to 1909, when the industrialization process had gathered steam. The reason is that although differences in labor productivity due to differences in industrial structure increased during this period, within-industry productivity differences in manufacturing and services did not rise further or in fact declined. A likely reason, it was suggested, was active investment in rural areas as part of the "regional industrialization ideology," which mitigated labor productivity differences.

Finally, the period from 1909 to 1925 was characterized by a decrease in prefectural income inequality. However, because this period spans the World War I boom and subsequent recession and we do not have any detailed data, it is difficult to draw any firm conclusions regarding the role of structural change in changes in regional inequality. That being said, while the reasons may be unclear, what we can say is that within-industry productivity differences declined during this period.

Overall, the analysis in this chapter suggests that changes in industrial structure and in within-industry differences in labor produc-

tivity played a key role in shaping trends in spatial income inequality in Japan. Of particular interest is the fact that the contribution of productivity differences as a result of differences in industrial structure—like income inequality overall—follows an inverted U curve, while the other two determinants we examined here, within-industry productivity differences on the hand and the gainfully occupied population share on the other, worked in opposite directions over time. That is, whereas the occupied population share initially worked in the direction of mitigating income differences and increasingly worked in the direction of adding to them, the contribution of within-industry productivity differences almost consistently declined, thus working in the direction of convergence. Thus, it could be said that the inverted U curve in prefectural income inequality is the result of the interplay of countervailing forces rather than one particular mechanism.

Finally, it is worth noting that in many regards the analysis here only represents the starting point of a detailed examination of the spatial pattern of industrialization in pre-war Japan. Much work remains to be done, for example, in terms of relating the trends in within-industry productivity differences observed here to existing research and historical sources on technology imports and the spread of technology. Such issues are left for future research.

Chapter 4

Growth, Migration, and Convergence

4.1 Introduction

The examination of regional inequality in Japan in Chapter 2 showed that the coefficient of variation in per capita GPP initially increased during the first few decades of Japan's economic development before subsequently decreasing again during the post-war period. In other words, regional inequality in Japan, like in most Western countries, followed an inverted U shape. This trend may have given rise to the impression that, after becoming more concentrated, economic activity in Japan became increasingly evenly dispersed again.

However, nothing could be further from the truth. As this chapter will show, economic activity in Japan has in fact become increasingly concentrated throughout the period, clustering in a few major urban conglomerations led by Tokyo and its surrounding prefectures. Underlying and reinforcing this growing regional concentration in economic activity is the growing concentration of Japan's population in these areas as a result of large-scale rural-urban migration that started at the beginning of our observation period, the early Meiji era, and has continued until this day.

This large-scale rural-urban migration has affected regional economic development and prefectural inequality in numerous ways, and

this chapter focuses on some of them. Specifically, the first issue that will be examined is the role that migration has played in trends in regional inequality. As the previous chapters have already alluded, developments in regional inequality overall—that is, the inverted U curve—is the result of a number of overlapping trends, with some of them working in the direction of divergence and others in the direction of convergence. The analysis here will show that more or less throughout the entire observation period interprefectural migration has worked in the direction of convergence. This means that migration mitigated increases in regional inequality during the first few decades of Japan's modern economic development, which may be one reason why, even at its peak, regional inequality in Japan was relatively low compared to other countries. Moreover, migration substantially contributed to convergence when regional inequality did fall, with the contribution being particularly large during the high-speed growth era from 1955 to ca. 1970.

Another issue that will be examined is the impact of migration on prefectural human capital. That is, while migration on the one hand may contribute to convergence through the equalization of capital-labor ratios, at the same time it may have a countervailing impact on regional inequality through "brain drain" effects. In other words, if it is primarily those with higher human capital that migrate from poorer to richer prefectures, this would lead to divergence in prefectural incomes. The evidence, however, suggests that although prefectural differences in labor quality in the post-war period (to which our analysis of labor quality is confined), did work in the direction of divergence rather than convergence, no clear relationship between differences in labor quality and migration can be observed. For instance, although Osaka experienced substantial in-migration, many of those migrants appear to have been less well educated.

A third issue related to migration that is of considerable interest not only from a historical perspective, but also in terms of Japan's future, is the link between migration and prefectural age demographics and the implications thereof for regional inequality. Migration affects the demographic age composition not only directly, since it is mainly younger cohorts that migrate, but also indirectly through the longer term effects on birth rates, since these younger cohorts will have children. Our analysis shows that migration has had a clear

impact on prefectures' demographic structure, with poorer regions that experienced substantial out-migration having substantially older populations than richer regions that experienced in-migration. We further find a clear correlation between prefectures' aged population ratio (the share of the population aged 65 and over) and prefectures' per capita GPP and labor productivity. Careful analysis, however, suggests that the link between the aged population ratio and labor productivity does not reflect a causal relationship from the aged population ratio to productivity—i.e., that population aging leads to a decline in productivity—but rather the persistence of productivity differences over time. That is, prefectures with low relative productivity today tended to have low productivity in the past, which led to out-migration in the past and hence explains the current correlation between the aged population ratio and productivity.

Thus, migration has shaped the pattern of regional inequality in Japan in numerous ways, and the following sections address these different issues in turn.

4.2 Regional growth, size of economic activity, and migration

The examination of per capita GPP in Chapter 2 showed that regional income inequality increased during the initial phase of industrialization from 1874 onward, with the coefficient of variation peaking in 1950 following the devastation of World War II (see Figure 2.1 in Chapter 2). Following World War II, there have been strong forces of convergence, leading to a rapid decline in regional inequality in per capita GPP during most of the period.

At the same time, however, the distribution of economic activity and of the population has become more and more unequal. Specifically, more or less from the start of our observation period in 1874, both economic activity and Japan's population have gravitated toward prefectures containing the major urban agglomerations, Tokyo and, to a lesser extent, Osaka, as well as the area often referred to as Japan's industrial belt between them, especially Aichi (containing Nagoya) and Shizuoka prefectures. On the other hand, prefectures in rural areas of Japan have tended to decline in economic importance. This section looks at these developments in greater detail.

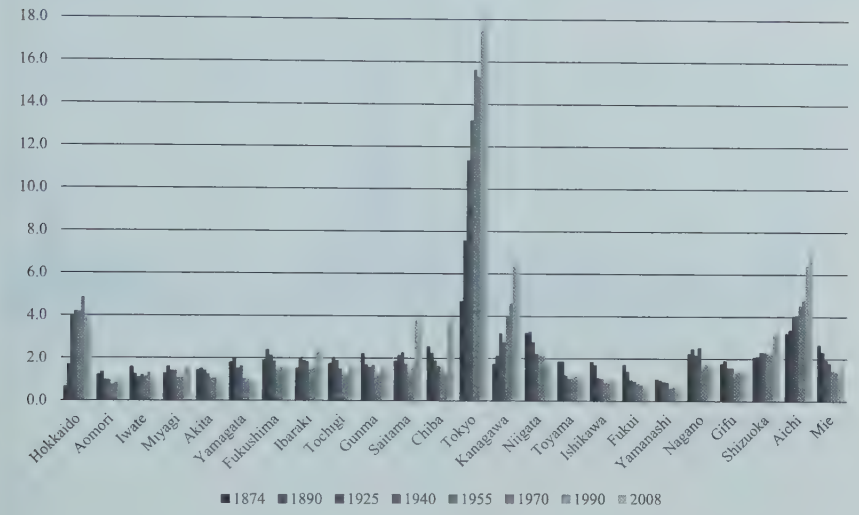
Starting with patterns in the distribution of economic activity, Figure 4.1 shows prefectures' share in national GDP for selected years from 1874 to 2008. The first thing that immediately stands out is the overwhelming and growing dominance of Tokyo throughout most of the period, reflecting its status as Japan's capital since the Edo period (1603–1868) and the undisputed center of the country's political, cultural, and economic life. It is followed by Osaka, whose share in national GDP was in fact slightly larger than that of Tokyo in 1874 and 1890 and, like Tokyo's, increased thereafter. However, reflecting what has been referred to as "Osaka's Tokyo problem" (Hill and Fujita, 1995), the city's economic importance has declined since the 1970s as industry and management functions shifted to Tokyo or the Kanto region, which includes the prefectures adjacent to Tokyo, namely Kanagawa, Saitama, and Chiba, so that the Kanto region together today accounts for almost a third of Japan's economic output. However, while the economic weight of Kanagawa, which contains Yokohama, the major port for Tokyo following the opening up of the country in the 1850s, increased throughout the period until the 1980s, that of Saitama and Chiba actually declined during (parts of) the pre-war period and only started to increase substantially during Japan's era of high-speed growth (1955–1973) as Tokyo began to burst its seams.

Outside the Kanto region, the only prefectures that have seen more or less consistent growth in their share in national GDP are Shizuoka and Aichi, both of which contain major industrial agglomerations, while Hiroshima (after an initial drop between 1874 and 1890) managed to maintain its share throughout. Fukuoka, on the other hand, saw its share increase substantially during the pre-war period as it became a major center for heavy industry, but then fell back almost to its level at the beginning of the period.

Mirroring the growing economic weight of the Kanto region and, to a lesser extent, Shizuoka and Aichi is the long-term decline in the national output of many rural prefectures, particularly on the Japan Sea side of Honshu (e.g., Akita, Yamagata, and Niigata), on Shikoku (e.g., Ehime and Kochi), and on Kyushu (e.g., Saga, Nagasaki, and Kumamoto). What these prefectures have in common is that they all are relatively remote (and often relatively isolated through mountains or the sea) from what can be described as Japan's main artery of economic activity stretching along the Pacific coast of Honshu.[1]

Figure 4.1 Prefectures' share in national GDP (in %)

(a) Hokkaido to Mie



(b) Shiga to Okinawa

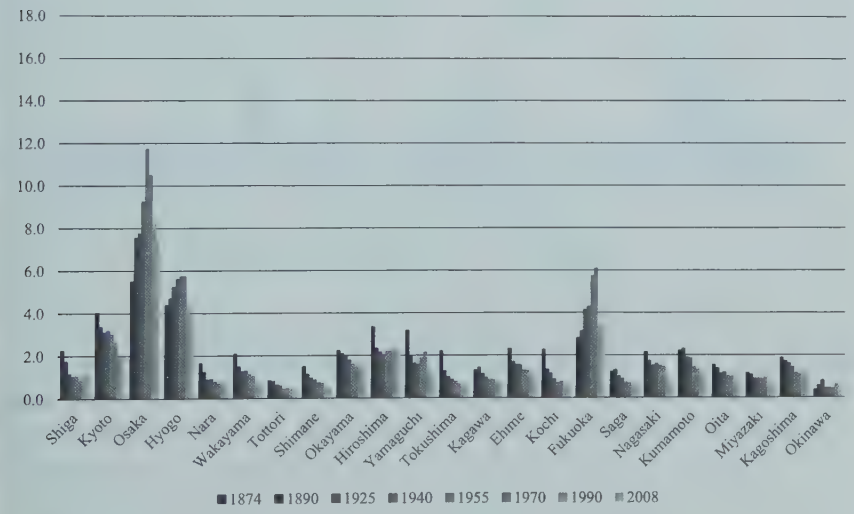
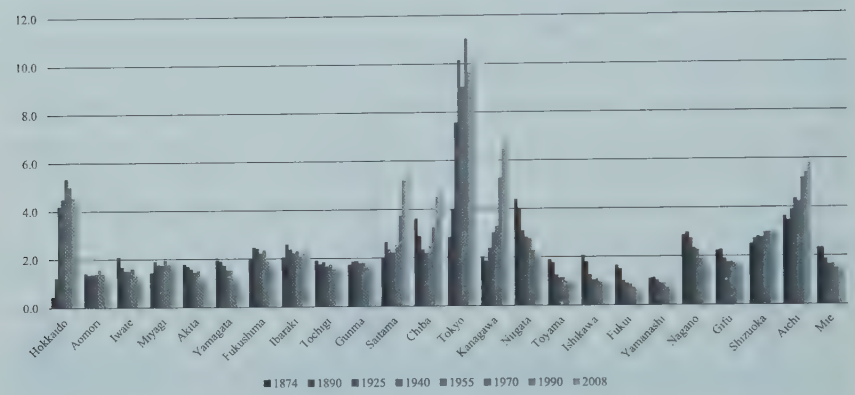
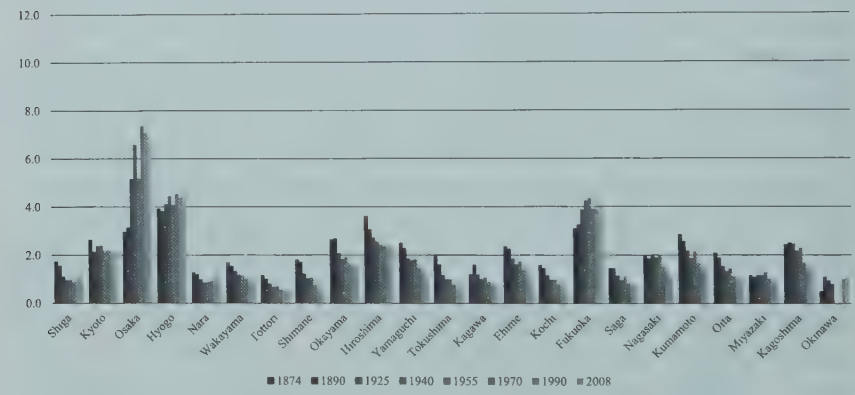


Figure 4.2 Prefectures' share in national population (in %)

(a) Hokkaido to Mie



(b) Shiga to Okinawa



Next, turning to the regional distribution of Japan's population over time, shown in Figure 4.2, the general pattern unsurprisingly is quite similar to that regarding economic activity. That is, Tokyo accounts for the largest population share, and that of adjacent prefectures (Saitama, Chiba, Kanagawa) has grown steadily; Aichi's popula-

[1] The decline in the economic weight of Kyoto, as well as Hyogo during the post-war period, which form part of the Greater Osaka region, likely reflects commuting to Osaka as well as the relative decline of Osaka.

tion share also increased steadily (while that of Shizuoka remained more or less unchanged); and remote rural prefectures have seen a long-term decline in their population shares.

However, there are also a number of notable differences. First, the trends in population shares over time are considerably smoother than those in output shares. That is, prefectures generally have seen their population shares increase, decrease, or remain stable more or less throughout the entire period. The major exceptions are Tokyo and Osaka. In Tokyo's case, the population share peaked around 1970 and has decreased slightly since as the city reached its physical limits and the population spilled over into the neighboring prefectures. Similarly, Osaka's share also peaked around 1970, while that of its neighbors, Kyoto and Hyogo, remained stable, which contrasts with their declining share in national output.

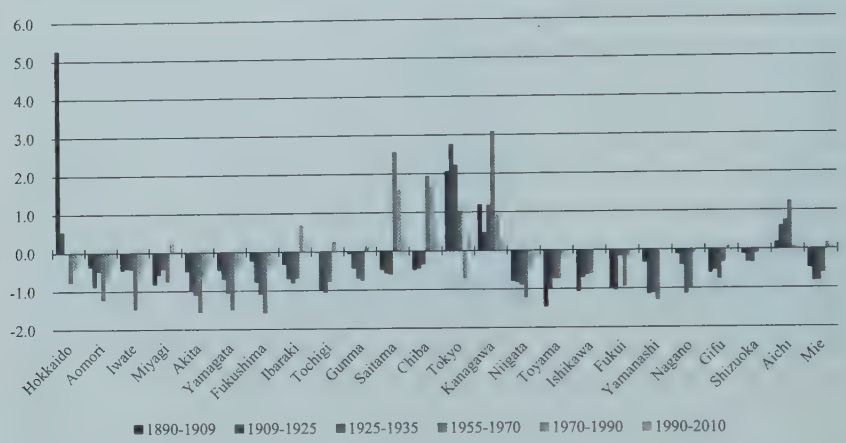
This latter phenomenon highlights the second notable difference between Figures 4.1 and 4.2: namely the divergence between output and population shares for prefectures in the two major urban conglomerations—Greater Tokyo and Greater Osaka—reflecting the role of commuting. For instance, while Tokyo in 2008 accounted for almost 18% of national output, it comprised only about 10% of the population. Conversely, the bed town prefecture of Saitama accounted for less than 4% of national GDP, but for almost 6% of the population. In contrast, outside the two urban conglomerations, prefectures' shares in national output and population rarely diverge by more than 0.2 percentage points.

Although natural rates of population change have differed across prefectures throughout the period considered here, the main driving force of the different population trends is migration. As shown in Figure 4.3, which depicts net annual migration rates, most prefectures experienced sustained out-migration, starting in 1890–1909, the earliest period for which we can estimate migration data, and continuing throughout the pre- and post-war periods.[2] In fact, out-migration in some prefectures was so intense that between 1890 and 1940, the pre-

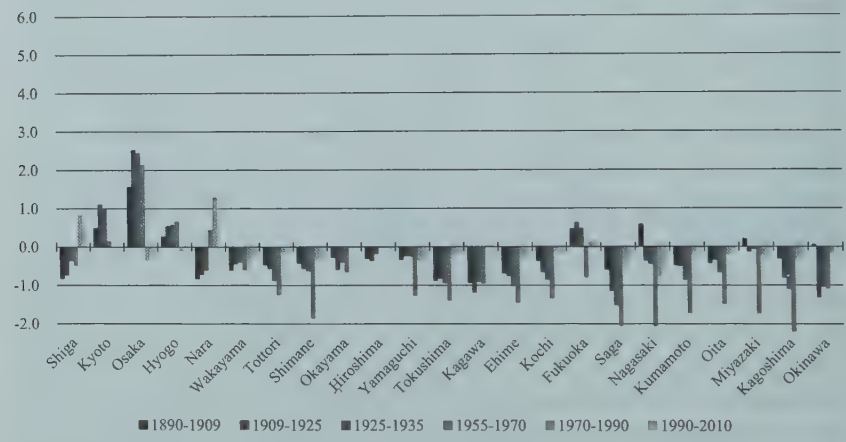
[2] For a variety of reasons, data on internal migration in Japan are not readily available and we had to estimate them. A description of our estimation approach is provided in the Appendix to this chapter. Due to data limitations, we were unable to estimate net migration for the period 1935–1955.

Figure 4.3 Net migration by prefecture (average annual rate in %)

(a) Hokkaido to Mie



(b) Shiga to Okinawa



fectural population hardly grew at all, although Japan's population overall increased by 80% during the same period. Examples are Shimane, Ishikawa, and Fukui prefectures, all of which are on the Japan Sea side of Honshu and whose populations rose by less than 7% during this period.

However, as can be seen in Figure 4.3, the highest annual rates of

migration for most prefectures can be observed during the high-speed growth era from 1955 to ca. 1970, which is also the period when inter-prefectural migration for Japan as a whole accelerated, reaching a peak of around 4% in 1970.[3] During this period, prefectures in the Tohoku region (Aomori, Iwate, Akita, Yamagata, Fukushima), the Japan Sea side of western Honshu (Tottori and Shimane), Shikoku (Tokushima, Kagawa, Ehime, Kochi), and Kyushu (Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima) all registered annual rates of net out-migration of close to or more than 1%. However, although the pace may have been slower, out-migration from these prefectures can essentially be seen from the beginning of our observation period; moreover, in most cases, it continues until today, albeit at comparatively low rates.

The out-migration from these rural prefectures is mirrored by high rates of in-migration in the urban prefectures, especially (Greater) Tokyo and (Greater) Osaka as well Aichi. Looking at the developments in greater detail, we find that both Tokyo and Osaka registered high rates of in-migration until the end of the high-speed growth era. In the case of (Greater) Tokyo, the figure suggests that during the pre-war period the prefectures surrounding the capital were subject to the same kind of rural-urban migration as more outlying prefectures, while during the post-war period, they started to form the Greater Tokyo region, attracting migrants from other parts of the country. The pattern for the (Greater) Osaka region is relatively similar, although three of the five prefectures making up the Greater Osaka region (Osaka, Kyoto, Shiga, Hyogo, and Nara), have seen out-migration since the 1970s, so that the population share of the region as a whole has in fact slightly declined, reflecting the region's "Tokyo problem."

Research on the determinants of internal migration shows that, unsurprisingly, migration responds to economic opportunities, although natural and cultural amenities also play a role. Specifically, at the early stages of the development process, modernization and economic growth go hand-in-hand with the movement of labor out of agricul-

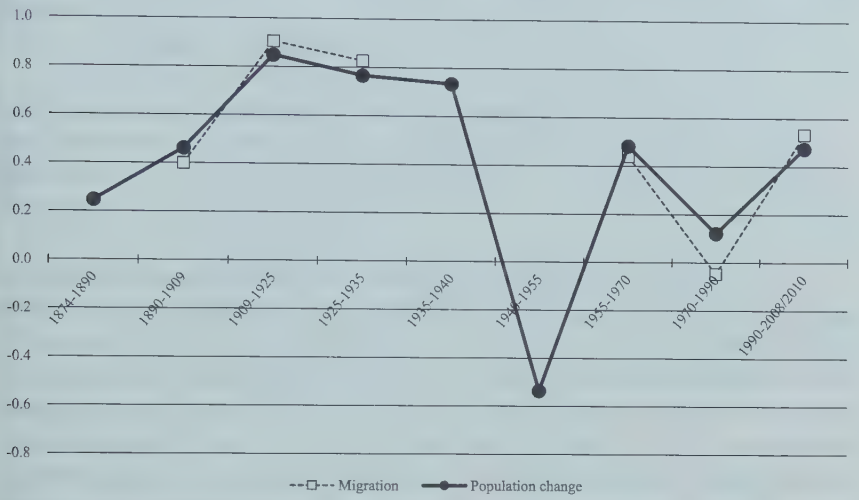
[3] Figure from "Report on Internal Migration in Japan" (Table 1-1), Statistics Bureau. Available online (in Japanese) at: http://www.e-stat.go.jp/SG1/estat/List.do?bid=000001039741&cycode=0 (accessed December 10, 2014).

ture into modern sectors of the economy, resulting in a redistribution of the population from rural to urban areas. There is a vast body of both theoretical and empirical literature on such rural-urban migration, largely focusing on developing countries and summarized in Taylor and Martin (2001), which suggests that differentials in average wages or income between regions as well as differences in unemployment rates play a critical role in explaining migration flows. Similarly, studies focusing on developed economies show that relative wages and employment opportunities are major determinants. In addition, they highlight that regional differences in the returns to skills (Borjas, Bronars, and Trejo, 1992) and amenities Treyz et al. (1993) are also important.

Unfortunately, a detailed analysis of the determinants of migration patterns in Japan is beyond the scope of this study. A snapshot of the reasons for moving, however, is provided by Otomo (1983, 1990). Citing a survey on reasons for migration conducted in 1981, he finds that by far the most important reason for interprefectural migration is "employment" (cited by 65.0% of respondents), followed by "family reasons" (10.0%), "marriage" (8.5%), and "schooling" (5.6%). The survey thus suggests that economic opportunities are a major reason for interprefectural migration, and to examine the link, we calculated the coefficient of correlation between per capita GPP at the beginning of various subperiods and the annual rate of population change during the period as well as the annual rate of net migration (where available).[4] The result is presented in Figure 4.4 and shows that from the start of the period in 1874 onward, there is a clear correlation between the two. While the correlation is relatively low during the initial period, it is especially high during first few decades of the 20th century and during the high-speed growth era, indicating that prefectures with a low per capita GPP at the beginning of the period experienced slow (and in some cases negative) rates of population growth and high rates of out-migration, while prefectures with a high per capita

[4] In addition, for the post-war period, Section 4.5 below shows that there was quite a high correlation between prefectures' relative labor productivity and the net rate of in-migration of younger cohorts. Given that wages tend to be closely related to productivity, this indicates that migration patterns closely reflect economic opportunities.

Figure 4.4 Coefficient of correlation between per capita GPP at the beginning of the period and the annual rate of migration/population change during the period



Notes: For the last interval, the observation period for the rate of migration is 1990–2010, while for the rate of population change it is 1990–2008. Data for Okinawa for the period 1955–1971 are not available, so that Okinawa is excluded in the calculations for intervals overlapping with this period.

GPP experienced high rates of population growth and in-migration. The correlation turned negative during World War II, when—as a result of the war—large parts of the population were forced to flee the cities, and was close to zero during 1970–1990, likely to a considerable extent reflecting out-migration from Tokyo and Osaka, which have a very high per capita GPP, to surrounding prefectures (especially Saitama and Chiba in the case of the former, and Shiga and Nara in the case of the latter), which have a comparatively low per capita GPP (largely as a result of commuting).

In sum, over the past 130 years or so, Japan has experienced considerable internal migration from poorer, rural prefectures to richer, urban prefectures, bringing about a substantial redistribution of the population and economic activity, with both having become increasingly concentrated in the Kansai and especially the Kanto region. At the same time, however, as the next section will show, this redistribution of the population through migration has almost consistently

worked in the direction of reducing prefectural differences in per capita GPP.

4.3 Migration as an engine of regional convergence

As seen in Chapter 2, regional inequality in Japan followed an inverted U curve; that is, inequality in per capita GPP first tended to increase during the pre-war period before decreasing in the post-war period. The aim of this section is to examine the role that migration played in the development of regional inequality overall.

Convergence or divergence in regional per capita output (GPP in our case) can be driven by changes in both the numerator (GPP) and in the denominator (population). In turn, changes in a given prefecture's share in Japan's total population result from the combined effects of differences in fertility, mortality, and net migration across prefectures. Our estimates (not shown) indicate that natural rates of population increase tended to be higher in rural than in urban prefectures during the pre-war period, but the pattern gradually reversed in the post-war period, and since the start of the millennium the natural rate of population change has actually been negative in rural prefectures reflecting the aging of the population, while it has remained slightly positive in Osaka, Tokyo and adjacent prefectures, and Aichi. However, as seen in the previous section, the key driver of differential rates of population growth across prefectures was migration, and the purpose here is to assess the contribution of migration to changes in regional inequality.

In order to do so, we focus on changes in the difference in per capita GPP between the richest and poorest prefectures and decompose these changes into the contribution of various components. Specifically, as in Chapters 2 and 3, we concentrate on the top and bottom 20% or 50% of prefectures in terms of cumulative population and, for the post-war period, look at the contribution of differences in the growth rates of TFP, capital, man-hours, labor quality, and population. In addition, we further decompose differences in the growth rate of man-hours into differences in changes in the share of the gainfully occupied population and in the working hours per employed person, and differences in population growth rates into differences in the rate of natural population growth and migration. Due to the lack of data on

capital stock, working hours per employed person, and labor quality, the analysis for the pre-war period is limited to examining the contribution of changes in the share of the gainfully occupied population and differences in population growth rates.

We conduct our decomposition analysis at the macro level, i.e., without taking into account the role of changes in industrial structure and sectoral productivity in each prefecture. We assume a constant-returns-to-scale production function:

$$Y_{r,t} = TFP_{r,t} F(Z_{r,t}, q_{r,t} h_{r,t} L_{r,t}), \tag{4.1}$$

where subscripts r and t stand for the prefecture and year, and Y denotes output, TFP the TFP level, hL is labor input in man-hours, consisting of the working hours per employed person, h, multiplied by the number of employed persons, L, and q is an index of labor quality. We assume that the production function is constant and identical across prefectures.

Dividing both sides of (4.1) by the total population of prefecture r, $N_{r,t}$, we obtain

$$\frac{Y_{r,t}}{N_{r,t}} = TFP_{r,t} F\left(\frac{Z_{r,t}}{N_{r,t}}, \frac{q_{r,t} h_{r,t} L_{r,t}}{N_{r,t}}\right). \tag{4.2}$$

Employing a log-linear approximation of equation (4.2), we obtain

$$\begin{aligned} \ln\left(\frac{\frac{Y_{r,T}}{N_{r,T}}}{\frac{Y_{r,0}}{N_{r,0}}}\right) &= -\theta^K \ln\left(\frac{N_{r,T}}{N_{r,0}}\right) + (1-\theta^K)\ln\left(\frac{\frac{L_{r,T}}{N_{r,T}}}{\frac{L_{r,0}}{N_{r,0}}}\right) \\ &+ \ln\left(\frac{TFP_{r,T}}{TFP_{r,0}}\right) + \theta^K \ln\left(\frac{Z_{r,T}}{Z_{r,0}}\right) + (1-\theta^K)\ln\left(\frac{h_{r,T}}{h_{r,0}}\right) + (1-\theta^K)\ln\left(\frac{q_{r,T}}{q_{r,0}}\right), \end{aligned} \tag{4.3}$$

where θ^K denotes the capital income share, which we assume to be constant and identical across prefectures.

In equation (4.3), the change in per capita GPP on the left-hand side is decomposed into the contribution of the terms on the right-hand side. The first two terms reflect the effects of migration. Specifically, assuming that all other factors remain constant over time, in-migration will lead to an increase in the population, which will reduce per capita income by reducing the per capita capital stock. This effect

of migration is denoted by the first term on the right-hand side. Further, given that most individuals migrate for work, migration will likely increase the share of the gainfully occupied population, which will raise per capita GPP. This effect of the change in the share of the gainfully occupied population is denoted by the second term. It is these two factors, which we call the (1) population effect and the (2) demographic effect of migration, that are the main focus of this section. The other four terms on the right-hand side denote the effects of (3) TFP growth, (4) capital deepening, (5) growth in working hours per worker, and (6) growth in labor quality, respectively. We call the sum of these four factors the productivity effect. It should be noted that this productivity effect is not entirely disconnected from migration, so that the distinction of the effects is not as clear-cut as this classification suggests. For example, both (5) growth in working hours per worker and (6) growth in labor quality may be influenced by migration and demographic change.

For the post-war period we can calculate the six factors separately (TFP is calculated as the residual). However, for the pre-war period, we can only calculate (1) the population effect, (2) the effect of changes in the share of the gainfully occupied population, and the total productivity effect (i.e., the sum of (3) TFP growth, (4) capital deepening, (5) growth in working hours per worker, and (6) growth in labor quality), where the total productivity effect is calculated as the residual.

To examine how the different factors contributed to convergence in per capita GPP, we focus on the top and bottom 20% or 50% of prefectures in terms of per capita GPP and cumulative population. That is, we rank prefectures in terms of their per capita GPP and for the top 20% include all top ranked prefectures until they make up 20% of Japan's total population. The same procedure is employed for the bottom 20% and the top and bottom 50%. The annual average convergence rate between the top income group of prefectures (group A) and the bottom income group (group B) can be expressed by

$$\begin{aligned}
&\frac{1}{T}\left(\ln\left(\frac{\frac{Y_{A,T}}{N_{A,T}}}{\frac{Y_{B,T}}{N_{B,T}}}\right)-\ln\left(\frac{\frac{Y_{A,0}}{N_{A,0}}}{\frac{Y_{B,0}}{N_{B,0}}}\right)\right)=-\frac{1}{T}\theta^{K}\left(\ln\left(\frac{N_{A,T}}{N_{A,0}}\right)-\ln\left(\frac{N_{B,T}}{N_{B,0}}\right)\right)\\
&+\frac{1}{T}(1-\theta^{K})\left(\ln\left(\frac{\frac{L_{A,T}}{N_{A,T}}}{\frac{L_{A,0}}{N_{A,0}}}\right)-\ln\left(\frac{\frac{L_{B,T}}{N_{B,T}}}{\frac{L_{B,0}}{N_{B,0}}}\right)\right)\\
&+\frac{1}{T}\left(\ln\left(\frac{TFP_{A,T}}{TFP_{A,0}}\right)-\ln\left(\frac{TFP_{B,T}}{TFP_{B,0}}\right)\right)+\frac{1}{T}\theta^{K}\left(\ln\left(\frac{Z_{A,T}}{Z_{A,0}}\right)-\ln\left(\frac{Z_{B,T}}{Z_{B,0}}\right)\right)\\
&+\frac{1}{T}(1-\theta^{K})\left(\ln\left(\frac{h_{A,T}}{h_{A,0}}\right)-\ln\left(\frac{h_{B,T}}{h_{B,0}}\right)\right)+\frac{1}{T}(1-\theta^{K})\left(\ln\left(\frac{q_{A,T}}{q_{A,0}}\right)-\ln\left(\frac{q_{B,T}}{q_{B,0}}\right)\right).
\end{aligned}\tag{4.4}$$

As mentioned, for the post-war period, the term for the difference in TFP growth is calculated as the residual. Similarly, for the pre-war period, the productivity effect (the sum of the last four terms) is calculated as the residual.

For 1890–1940 and 1955–2008, we can also decompose the contribution of differences in population growth rates—the first term in equation (4.4)—into differences in the social rate of population growth (i.e., migration) and the natural rate of population growth:

$$\begin{aligned}
&-\frac{1}{T}\theta^{K}\left(\ln\left(\frac{N_{A,T}}{N_{A,0}}\right)-\ln\left(\frac{N_{B,T}}{N_{B,0}}\right)\right)\\
&\approx-\frac{1}{T}\theta^{K}(n_{A,0,T}-n_{B,0,T})-\frac{1}{T}\theta^{K}(m_{A,0,T}-m_{B,0,T}),
\end{aligned}\tag{4.5}$$

where n stands for the rate of natural population change and m for migration.

For the decomposition we assume that the capital income share, θ^{K}, is 1/3. In addition, when calculating the left-hand side of equation (4.4), we assume that the GPP deflator of all prefectures changed in a similar manner (i.e., the inflation rate in terms of the GPP deflator is identical across prefectures).

The results are shown in Tables 4.1 and 4.2, with the former comparing the top and bottom 20% of prefectures in terms of cumulative population, and the latter the top and bottom 50% (in other words, the second table divides all prefectures into two groups in terms of

Table 4.1 Decomposition of convergence in per capita GPP, top and bottom 20%

		1874–1890	1890–1909	1909–1925	1925–1935	1935–1940	1940–1955	1955–1970	1970–1990	1990–2008	1874–2008	1874–1940	1955–2008
Difference in per capita GPP growth	a + b	−0.261	−0.017	−0.812	0.941	3.367	−0.828	−0.722	−0.840	0.448	−0.545	−0.377	−0.674
Diff. in pop. growth and in change in gainfully occ. pop. share	a = (1) + (2)	−0.292	0.432	−0.473	−0.578	0.439	0.622	−0.434	0.235	0.393	−0.209	−0.431	−0.168
Difference in population growth	(1) = (1.1) + (1.2)	−0.150	0.424	−0.616	−0.675	−0.742	0.373	−0.939	0.122	−0.114	−0.326	−0.466	0.350
Difference in net migration	(1.1)	—	−0.431	−0.699	−0.805	−0.873	—	−0.912	−0.003	−0.083	—	—	−0.288
Difference in natural population change	(1.2)	—	0.006	0.083	0.130	0.131	—	−0.027	−0.118	−0.031	—	—	−0.063
Difference in change in gainfully occ. pop. share	(2)	0.142	−0.008	0.143	0.097	0.304	0.248	0.504	0.357	0.279	0.118	0.036	0.182
Difference in productivity growth	b = (3) + (4) + (5) + (6)	0.031	0.415	−0.340	1.519	−2.928	−1.450	−0.287	−1.075	−0.055	−0.336	0.053	−0.506
Difference in TFP growth	(3)	—	—	—	—	—	—	−1.528	−0.535	0.263	—	—	−0.545
Difference in capital stock growth	(4)	—	—	—	—	—	—	0.709	−0.447	−0.282	—	—	−0.064
Diff. in growth in working hours per emp. person	(5)	—	—	—	—	—	—	0.238	−0.214	−0.132	—	—	−0.058
Difference in labor quality growth	(6)	—	—	—	—	—	—	0.294	0.120	0.096	—	—	0.161

Note: The table shows the annual percentage rate of change in the difference between the per capita GPP of the top and bottom prefectures and the contribution of changes in the difference in the various components between the top and bottom prefectures.

Table 4.2 Decomposition of convergence in per capita GPP, top and bottom 50%

		1874–1890	1890–1909	1909–1925	1925–1935	1935–1940	1940–1955	1955–1970	1970–1990	1990–2008	1874–2008	1874–1940	1955–2008
Difference in per capita GPP growth	a+b	−0.558	0.076	−0.528	1.066	−1.711	−0.666	−0.598	−0.547	−0.399	−0.380	−0.210	−0.511
Diff. in pop. growth and in change in gainfully occ. pop. share	a=(1)+(2)	−0.122	−0.276	−0.259	−0.251	−0.537	0.331	0.176	0.257	0.209	0.096	0.251	−0.024
Difference in population growth	(1)=(1.1)+(1.2)	−0.079	−0.265	−0.319	−0.380	−0.485	0.207	−0.522	0.032	−0.087	−0.174	−0.267	−0.165
Difference in net migration	(1.1)	—	−0.240	−0.333	−0.442	−0.573	—	−0.464	0.073	−0.053	—	—	−0.122
Difference in natural population change	(1.2)	—	−0.025	0.014	0.063	0.089	—	−0.058	−0.041	−0.033	—	—	−0.043
Difference in change in gainfully occ. pop. share	(2)	−0.044	−0.011	0.059	0.128	−0.052	0.125	0.346	0.226	−0.123	0.078	0.016	0.141
Difference in productivity growth	b=(3)+(4)+(5)+(6)	−0.436	0.352	−0.268	1.317	−1.174	−0.998	−0.422	−0.805	−0.189	−0.284	0.041	−0.487
Difference in TFP growth	(3)	—	—	—	—	—	—	−0.994	−0.393	−0.053	—	—	−0.447
Difference in capital stock growth	(4)	—	—	—	—	—	—	0.249	−0.349	−0.133	—	—	−0.107
Diff. in growth in working hours per emp. person	(5)	—	—	—	—	—	—	0.213	−0.127	−0.040	—	—	−0.001
Difference in labor quality growth	(6)	—	—	—	—	—	—	0.110	0.065	0.036	—	—	0.068

Note: See Table 4.1.

their per capita GPP and examines the change between them). In addition to the various subperiods, we also show the average values for the observation period as a whole (i.e., 1874–2008) and for the pre-war and post-war periods (i.e., 1874–1940 and 1955–2008). Despite some differences, the results in the two tables show quite similar patterns, so that the description of the results will focus primarily on the comparison of the top and bottom 20%.

The first thing to note when looking at the results is that differences in per capita GPP growth between "leading" and "lagging" prefectures generally follow the pattern shown by the coefficient of variation presented in Figure 2.1 in Chapter 2. That is, regional inequality decreases (i.e., the difference in per capita GPP growth is negative) in most periods, with the major exception being the period 1925–1935 for the reasons discussed in Chapter 3. The only two periods for which no clear picture emerges are those at the very beginning of our observation period, 1874–1890 and 1890–1909. For both of these periods, the coefficient of variation in Figure 2.1 in Chapter 2 for per capita GPP shows an increase, while in Tables 4.1 and 4.2 only the result for the top and bottom 50% for 1890–1909 shows a rise. This indicates that while the variation in per capita GPP across individual prefectures increased during these periods, when grouping the richest and the poorest prefectures together, the gap between them actually diminished (1874–1890) or remained more or less unchanged (1890–1909). For all other periods, however, changes in the coefficient of variation and the difference in per capita GPP growth show very similar patterns with regard to the trend in regional inequality.

Turning to the decomposition results, for the pre-war period only data for the share of the gainfully occupied population and for population growth are available for all periods. However, for the period from 1890 to 1940, changes in the population can be broken down into those due to net migration and those due to natural population growth. The results indicate that during the pre-war period differences in population growth consistently worked in the direction of lowering per capita GPP inequality. Moreover, in all periods for which population growth can be broken down, it was net migration (rather than natural population growth) that was responsible for the fact that differences in population growth contributed to convergence in per capita GPP. Looking at the size of the contribution of net migration to differences

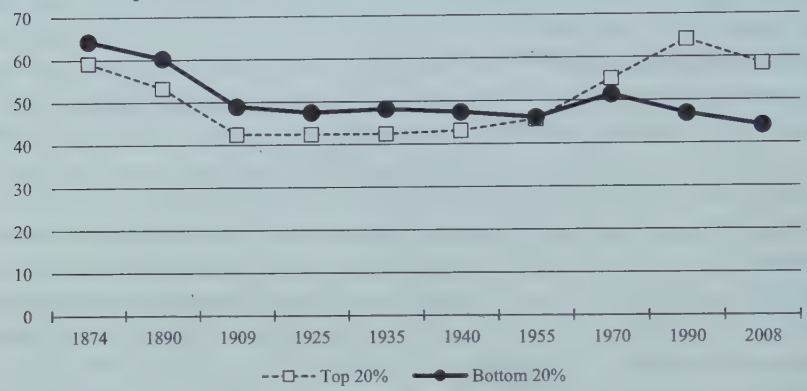
in per capita GPP growth, this is quite substantial in all subperiods. For example, between 1909 and 1925, per capita GPP between the top and bottom 20% of prefectures converged at an annual rate of 0.812%. Of this, 0.699 percentage points can be attributed to net migration. And even when prefectural incomes diverged between 1925 and 1935, or converged primarily due to other reasons between 1935 and 1940, migration substantially worked in the direction of convergence.

It comes as little surprise that during 1940–1955, the period of the war and its immediate aftermath, differences in population change worked in the opposite direction. During this period, population growth was higher in the bottom prefectures than in the top prefectures as people left the major cities following the destruction brought about by air raids during the war. However, during the high-speed growth era from 1955–1970, migration again played a key role in convergence. As seen in the previous section, annual migration rates during this period were extremely high, and the results in Table 4.1 indicate that together with convergence in TFP (contributing 1.528 percentage points), migration made a substantial contribution (0.912 percentage points) to convergence in per capita GPP.

Meanwhile, from around 1970, the role of migration in prefectural income convergence declined substantially, with the results for the 1970–1990 period likely reflecting the congestion effects described in the previous section—that is, the fact that Tokyo was bursting its seams and that is was "bed town" prefectures such as Saitama and Chiba with a low per capita GPP due to commuting that were among the largest recipients of in-migration. Migration did again make a small contribution to convergence in the final period, 1990–2008, but partly reflecting the much slower pace of migration, this contribution (0.083 percentage points) was much less substantial than in the past.

While the main interest of this chapter is the role of migration in convergence, it is also instructive to briefly look at the results for the other components. The only other series for which data throughout the entire observation period are available is the share of the gainfully occupied population, and Table 4.1 shows that changes therein initially worked in the direction of convergence, then divergence, and finally convergence again. Figure 4.5 depicting the share of the occupied population in the top and bottom 20% of prefectures helps to understand why this is the case. As already mentioned in Chapter 3, during

Figure 4.5 Share of gainfully occupied population in top and bottom 20% of prefectures (in %)



the early parts of our observation period the share of the occupied population was higher in the poorer prefectures as wives and other family members worked in agriculture, handicraft industries, and trade and services to make ends meet. However, the share of the gainfully occupied population started to fall from the beginning of our observation period in 1874, and this fall was relatively more rapid in the leading than the lagging regions, so that changes in the share worked in the direction of convergence. However, from around 1909, the share in the leading regions had stabilized around 42–45%, while it continued to fall in the lagging regions, working in the direction of per capita GPP divergence. In fact, in the post-war period, the occupied population share in the top prefectures—primarily urban prefectures such as Tokyo and Osaka, which attracted migrants in their prime working age—overtook that in the bottom prefectures, further contributing to divergence. Only in the last two decades (1990–2008) was this trend reversed, with the occupied population share dipping in the top prefectures, likely as a result of population aging.

Finally, the contribution of TFP growth, capital accumulation, improvements in labor quality, etc., to regional convergence during the post-war period will be examined in much greater detail in Chapters 5 and 6. Therefore, suffice it here to briefly highlight some of the key results in order to gain a sense of how migration fits into the overall picture. Starting with the high-speed growth era from 1955 to ca.

1970, the two key drivers of per capita GPP convergence during this period, as mentioned earlier, were TFP convergence and migration. In fact, all other factors worked in the direction of divergence. That is, leading prefectures enjoyed higher rates of physical and human capital accumulation (as shown by the positive values for the difference in capital stock growth and the difference in labor quality growth), thus substantially offsetting the overall convergence through TFP convergence and migration. Following the high-speed growth era, per capita GPP convergence continued, but the forces driving this convergence changed. Specifically, TFP remained the key driver of overall convergence in 1970–1990, but worked against convergence in 1990–2008, while capital accumulation worked toward convergence in both periods. Migration, as mentioned, played a negligible role in 1970–1990, and although it contributed to convergence in 1990–2008, the size of this contribution was much smaller than in earlier periods. Finally, labor quality improvements continued to work against convergence.

In sum, the decomposition results presented in Tables 4.1 and 4.2 show that developments in regional income inequality in Japan over the roughly 130 years covered by our observation period were driven by a number of overlapping forces of varying importance at different periods in time. Although data for a detailed decomposition for the pre-war period are unavailable, what data are available suggest that throughout most of the century from 1874 to ca. 1970, migration played a key role in either driving convergence in prefectural per capita GPP or mitigating divergence therein.

4.4 Migration and human capital

The finding that migration played a substantial role in driving convergence of per capita GPP in Japan conflicts with the results obtained by Barro and Sala-i-Martin (1992b), who analyzed regional convergence in the United States and Japan based a neoclassical growth model, regressing regional growth rates on initial income levels. They examined the contribution of migration to convergence by introducing migration rates into their convergence equations, but argue that their estimation results provide little evidence that population movements were of any importance. However, in adopting this approach, Barro and Sala-i-Martin (1992b) treat the growth process

as a "black box," where the sources of growth remain unknown. In other words, their approach is unable to take account of the various overlapping and countervailing factors that contribute to convergence. For instance, they assume that β, the coefficient of convergence, is the same across all regions, an assumption that they argue is justified if regions are similar in terms of the underlying parameters of technology and preferences. Yet, as the decomposition results in Tables 4.1 and 4.2 have shown, and as will be discussed in much greater detail in the following chapters, a key driver of convergence during the postwar period (up until around 1990) was the decline in TFP differences, which can be roughly regarded as differences in technology. On the other hand, changes in differences in the share of the gainfully occupied population (during the same period, up until around 1990) worked in the direction of increasing interprefectural GPP differences. Thus, opening up this "black box" and decomposing prefectural differences in growth into the constituent components shows that convergence is the result of a number of overlapping mechanisms (and therefore also no foregone conclusion), of which, as highlighted in the analysis above, migration was of considerable importance.

Our results in the preceding section also shed light on another issue, namely the "migration puzzle" discussed by Shioji (2001). Picking up on the result by Barro and Sala-i-Martin (1992b), he argued that the reason for their finding might be that the expected convergence effect of migration was offset by the impact of migration on prefectures' educational attainment and demographic structure. His empirical analysis suggested that migration indeed appeared to have affected regional human capital such that receiving regions gained in human capital per capita. Incorporating these findings into a convergence equation à la Barro and Sala-i-Martin, however, he finds that such "brain drain" effects are insufficient to offset the expected contribution of migration to β-convergence.

As mentioned in the previous section, the results in Tables 4.1 and 4.2 show that differences in labor quality growth did work in the direction of divergence. That is, average labor quality tended to improve at faster rates in richer than in poorer prefectures, thus working against convergence. How much of this is attributable to a "brain drain" —that is, the migration of highly skilled workers from lagging regions to leading regions—is difficult to say from our results,

since there are a large number of factors other than migration that affect regional improvements in labor quality, including prefectures' demographic age structure and university enrollment rates. What our results do show, however, is that at least during the high-speed growth era the contribution of differences in the improvement in labor quality was far outweighed by the contribution of migration. On the other hand, following the end of high-speed growth, the contribution of the former did tend to be somewhat larger than the latter.

Of considerable interest in this context is a study by Tokui, Makino, Kodama, and Fukao (2013a). Using detailed prefecture-level human capital data for Japan for the period 1970 to 2008, they find that although interprefectural migration of young workers had a substantial impact on the *quantity* of prefectural labor input, it had relatively little impact on the *quality* of prefectural labor input. Specifically, focusing on two representative cohorts, those aged 30–34 in 1990 and 2000, respectively, they look at the population composition by prefecture and sex 20 years earlier, i.e., 1970 and 1980, when these two cohorts were aged 10–14, that is, the age before they would have finished junior high school. The authors then calculate the educational composition of these cohorts by prefecture and sex at the time and, taking into account death rates, construct two sets of data for the number of employed persons in each prefecture classified by sex and educational attainment: the actually observed data and hypothetical data assuming that there had been no migration of labor. They then examine the effect of the migration of these cohorts on the quantity and quality of prefectural labor input by comparing the actual and hypothetical data.

The results are reproduced as Figures 4.6 and 4.7 below. The figures show the ratio of the hypothetical data to the actual data for the two cohorts, that is, those aged 10–14 in 1970 and 30–34 in 1990, and those aged 10–14 in 1980 and 30–34 in 2000. Thus, for Kagoshima, for example, Figure 4.6 shows that without migration the quantity of labor input in 1990 would have been 60% higher than it actually was, while for Saitama, it would have been more than 40% lower. Similarly, in 2000, Nagasaki's quantity of labor input would have been 50% higher, while Kanagawa's would have been ca. 35% lower. Migration thus had a substantial impact on the quantity of prefectural labor input.

In contrast, as illustrated in Figure 4.7, the impact on the quality of labor input was much smaller. Thus, in 1990, the quality of Ehime's labor input without migration would only have been 4.6% greater, while Saitama's would have been only 3.8% smaller than it actually was. On the other hand, in 2000, the quality of Fukui's labor input would have been 6.9% greater, while Saitama's again would have been 3.8% smaller than it actually was.

Looking at Figures 4.6 and 4.7 together shows that, as one would expect, prefectures in the Greater Tokyo area (Tokyo, Chiba, Kanagawa, and Saitama) had not only a higher quantity but also a higher quality of labor input as a result of migration than would otherwise have been the case. Yet, closer examination reveals that there does not appear to be a straightforward relationship between the impact of migration on the quantity and quality of labor input. For example, in Okinawa, where migration reduced the quantity of labor input between 1970 and 1990 relative to the counterfactual with no migration, the quality of labor input was nevertheless higher in 1990 than it would have been in the absence of migration. Conversely, in the case of Osaka, which experienced substantial labor inflows, the quality of labor input in 1990 was lower than it would have been in the absence of migration, suggesting that Osaka received a lot of relatively less educated migrants.

Thus, in order to ascertain whether there was any systematic pattern in the human capital impact of migration, Tokui, Makino, Kodama, and Fukao (2013a) examine the relationship between differences in the quality of labor input 20 years earlier on the one hand and the impact of migration in terms of the quantity and quality of labor input on the other. Figures 4.8 and 4.9 reproduce their results. On the horizontal axis, the figures show prefectures' labor quality level relative to Tokyo's (i.e., Tokyo = 1.00), the prefecture with the highest labor quality. On the vertical axis, the figures show the same values as those presented in Figures 4.6 and 4.7, i.e., the effect of migration on the quantity and quality of labor input.

Starting with the link between differences in labor quality and the quantitative impact of migration, Figure 4.8 shows that there is a clear negative relationship between the two. In other words, prefectures with relatively low labor quality 20 years earlier tended have experienced an outflow of labor in quantitative terms, while prefectures with

Figure 4.6 The impact of migration on the quantity of prefectural labor input (man-hours × quality)

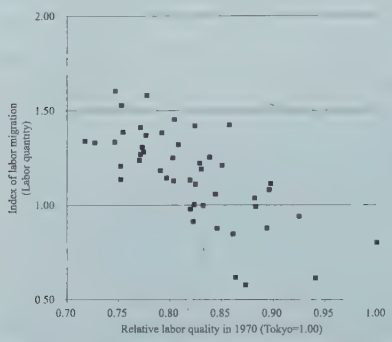
Source: Tokui, Makino, Kodama, and Fukao (2013a).

Figure 4.7 The impact of migration on the quality of prefectural labor input

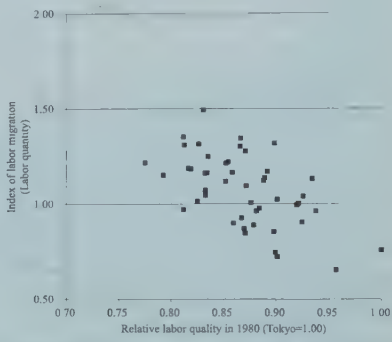
Source: Tokui, Makino, Kodama, and Fukao (2013a).

Figure 4.8 Migration and the concentration of human capital: Quantity (man-hours × quality)

(a) Cohort of those aged 30–34 in 1990



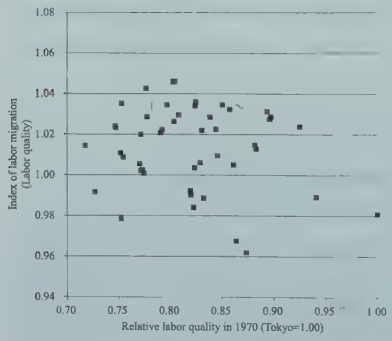
(b) Cohort of those aged 30–34 in 2000



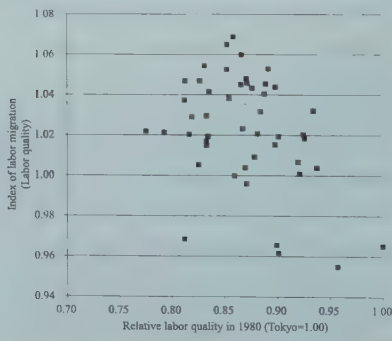
Note: The panels show the quality of prefectural labor input 20 years earlier (i.e., 1970 or 1980) on the horizontal axis (where Tokyo = 1.00) and the effect of migration on the quantity of prefectural labor input on the vertical axis.
Source: Tokui, Makino, Kodama, and Fukao (2013a).

Figure 4.9 Migration and the concentration of human capital: Quality

(a) Cohort of those aged 30–34 in 1990



(b) Cohort of those aged 30–34 in 2000



Note: The panels show the quality of prefectural labor input 20 years earlier (i.e., 1970 or 1980) on the horizontal axis (where Tokyo = 1.00) and the effect of migration on the quality of prefectural labor input on the vertical axis.
Source: Tokui, Makino, Kodama, and Fukao (2013a).

relatively high labor quality were likely to have experienced an inflow. This pattern holds for both 1990 and 2000 and indicates that, as one would expect, migration was generally associated with a growing con-

centration of labor in quantitative terms. (The correlation coefficients for the two years are −0.70 and −0.56 respectively.) On the other hand, looking at the link between differences in labor quality 20 years earlier and the impact of migration on labor quality in 1990 and 2000, Figure 4.9 suggests that no such relationship can be observed (correlation coefficient for 1990: −0.15) or is very weak at the most (correlation coefficient for 2000: −0.37). That is, prefectures that had relatively low labor quality 20 years earlier did not experience a substantial decrease in labor quality as a result of migration and vice versa. Put differently, although there was a clear tendency for labor to become increasingly concentrated in prefectures with higher labor quality, the evidence suggests that there was no similar concentration effect as a result of migration in terms of the quality of labor, suggesting that migration was not associated with a significant "brain drain" from lagging to leading regions.

Thus, combining the findings by Tokui, Makino, Kodama, and Fukao (2013a) and the decomposition results in Tables 4.1 and 4.2, it appears that the role of migration in convergence was not—or not to a meaningful extent—offset by a "brain drain," that is, the migration of highly skilled workers, from lagging regions to leading regions. Instead, it appears that human capital accumulation within leading prefectures was faster than in lagging prefectures. One likely reason is that most leading prefectures are urban prefectures, and urban prefectures tend to have higher university enrollment rates. Looking at data for 2008, prefectures such as Tokyo, Osaka, or Hiroshima have university enrollment rates (well) above the national average, while rural prefectures such as Kagoshima, Iwate, and Aomori have university enrollment rates well below the national average.[5] Examining why enrollment rates are higher in urban than in rural prefectures is beyond the scope of this study, but both supply and demand factors likely play a role: in Japan, leading universities are concentrated in the major cities, and city dwellers may put more emphasis on a university education due to better job prospects.

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[5] See, e.g., Ministry of Education, Culture, Sports, Science and Technology, *2009 White Paper on Education, Culture, Sports, Science and Technology*, chapter 2. Available online: http://www.mext.go.jp/b_menu/hakusho/html/hpab200901/detail/1305857.htm (accessed December 13, 2014).

While migration may not have directly contributed to the divergence in human capital through a "brain drain," it may nevertheless have contributed to it indirectly. The reason is that since it is mainly younger cohorts that tend to migrate, migration has played a key role in shaping the demographic age structure of prefectures, not only through the immediate influx of younger cohorts, but also through resultant higher birth rates. Combined with the higher enrollment rates in leading, urban prefectures, this means that not only a larger share of each cohort will have attended university, but also that—as a result of migration—the size of these cohorts will have been larger than in the absence of migration. The next section will look at the demographic impact of migration in greater detail.

4.5 Migration, demographic change, and regional inequality[6]

Japan's population is aging rapidly: the share of those aged 65 and over in the total population in 2013 stood at 25.1%, the highest in the world, and the speed of population aging in Japan is much faster than in the advanced European countries and the United States (Statistics Bureau, 2014). However, population aging in Japan is proceeding at an uneven pace across regions. In some prefectures, such as Akita and Shimane, population aging as measured by the ratio of those aged 65 and over is about 15 years ahead of Japan as a whole and 25 years ahead of Tokyo prefecture. To a large extent, these differences are the result of migration, both because migration affects the demographic age composition of prefectures directly (since it is mainly younger cohorts that migrate), and because of the longer term effects on birth rates (since these younger cohorts will have children). These demographic changes, in turn, potentially affect prefectures' economic performance (such as labor productivity) and hence trends in regional inequality. This section examines these issues in greater detail.

To get a sense of the extent to which demographic age structures

[6] The analysis in this section is based on research conducted as part of the RIETI project "Regional-Level Japan Industrial Productivity Database: Database Refinement and Its Analysis" (http://www.rieti.go.jp/en/projects/program/pg-05/010.html).

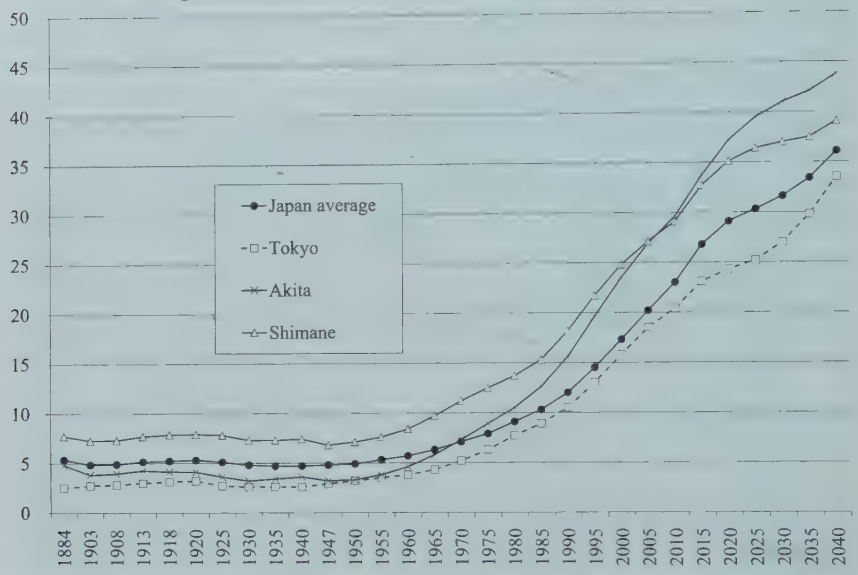
Figure 4.10 Aged population ratio by prefecture in 2010 (in %)

Source: *Population Census 2010*, Statistics Bureau, MIC.

differ across prefectures. Figure 4.10 shows the aged population ratio (the share of those aged 65 and over in the total population) by prefecture for 2010. The prefecture with the highest ratio is Akita with 29.6%, which is almost 7 percentage points higher than the national average (23.0%) and 9 percentage points higher than Tokyo's, although the prefecture with the lowest ratio is Okinawa, probably because of its high birth rate. Except for Okinawa, all other prefectures with an aged population ratio below the national average are either metropolitan areas, such as Tokyo, Osaka, Kanagawa, Aichi, Fukuoka, and Miyagi, suburbs of metropolises, such as Saitama, Chiba, and Shiga, or industrial districts around Tokyo, such as Ibaragi and Tochigi.

Next, Figure 4.11 shows how the aged population ratios of Akita, Shimane, Tokyo, and Japan as a whole have changed over time and how they are expected to change in the future. The figure shows that Akita and Shimane are about 15 years ahead of Japan as a whole and about 25 years ahead of Tokyo in terms of their aged population ratios.

Figure 4.11 Aged population ratio: 1884–2040 (in %)

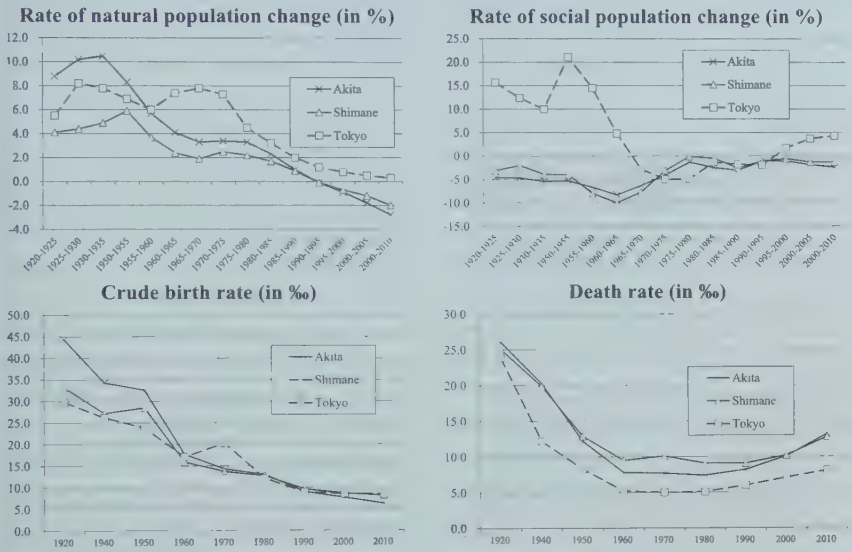


Sources: Data from 1884 to 1918 were estimated on the basis of the permanent domicile population. Data from 1920 to 2010 are based on the *Population Census* (various years), Statistics Bureau, MIC. Data from 2015 are projections by the National Institute of Population and Social Security.

Figure 4.11 also shows that from a historical perspective, Akita and Shimane are quite different from Japan as a whole. Shimane's aged population ratio has been more than double that of Tokyo and more than two-fifth above the national average throughout the entire period from 1884 to 2010. On the other hand, Akita's high aged population ratio is a more recent phenomenon. Until 1965, the ratio for Akita was below the national average, but it subsequently rapidly pulled ahead of the national average.

To examine why the aged population ratios of Akita and Shimane are so much higher than Tokyo's Figure 4.12 compares the rates of natural and social population change, the crude birth rates, and the death rates of these prefectures. The figure shows that there were substantial differences in the rate of social population change across the three prefectures from 1920 to 1970. Shimane and Akita experienced large out-migration during this period, and the out-migration

Figure 4.12 Comparison of demographic indicators for Akita, Shimane, and Tokyo: 1920–2010



Source: *Population Census* (various issues), Statistics Bureau, MIC.

rate was particularly high during Japan's high growth era from 1955 to 1970.

On the other hand, Tokyo experienced extremely rapid in-migration until the 1960s, including—as seen earlier—during the pre-war period. Population inflows to Tokyo gradually declined in the 1960s and even turned negative during the 1970s and 1980s due to the congestion phenomenon mentioned earlier.[7]

People are particularly likely to migrate in their teens or twenties. Therefore, out-migration will reduce the working age population and the crude birth rate, and will increase the aged population ratio for the following 30–40 years.[8] Figures 4.13 and 4.14 show the correlation

[7] It should be noted that Figure 4.12 does not help to explain why Shimane's aged population ratio was so high even in the pre-war period (Figure 4.11). One possible explanation is that Shimane's out-migration started much earlier than Akita's, but to verify this more long-term data than those shown in the figure would be necessary.

between the rate of social population change over each five year interval and the aged population ratio 40 years later by prefecture for both the pre-war and the post-war period. We find a negative and statistically significant correlation (at the 5% level) between in-migration and the aged population ratio 40 years later for all periods analyzed. Thus, migration has had a substantial impact on prefectures' age structure, which, in turn, helps to explain the developments in the rates of natural population change shown in Figure 4.12. While Akita and Shimane still had higher birth rates than Tokyo before 1960, this briefly reversed during the second baby boom around 1970, before birth rates became very similar from 1980 onward. At the same time, the death rate in Tokyo declined much faster than in the other two prefectures and has remained considerably lower since. Taken together, the trends mean that between 1955 and 1980 Tokyo had a considerably higher rate of natural population change than Akita and Shimane.

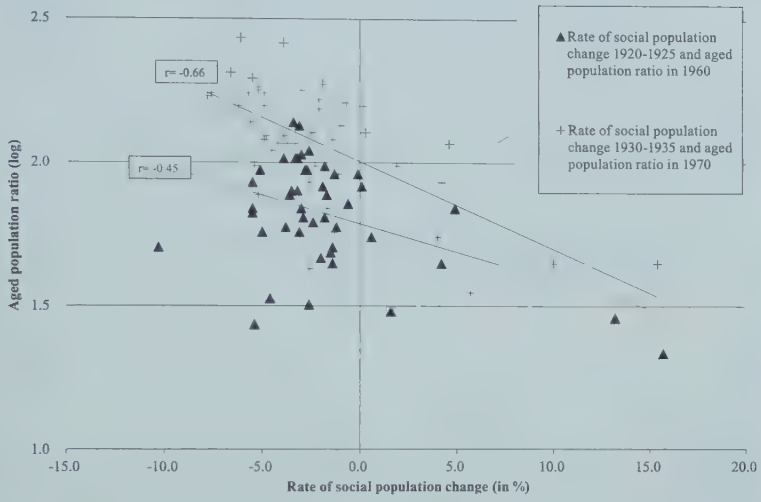
A key determinant of migration, as mentioned in Section 4.2, is economic opportunities—that is, the availability of jobs as well as higher wages. Figure 4.4, for example, showed that for much of the observation period, migration flows during a particular period were closely correlated with real per capita GPP at the beginning of the period; that is, prefectures with a higher per capita GPP tended to experience in-migration, and vice versa. Another way to examine the link between economic opportunities is to look at the correlation between the log of labor productivity relative to the national average and the net in-migration rate of each cohort in the 20 years from age 10–14 to age 30–34. Given that wages tend to reflect labor productivity, this correlation shows the link between relative wages and migration. Table 4.3 and shows that in all three subperiods during the post-war era, the correlation is quite high.

However, as closer inspection of Figure 4.3 above shows, out-

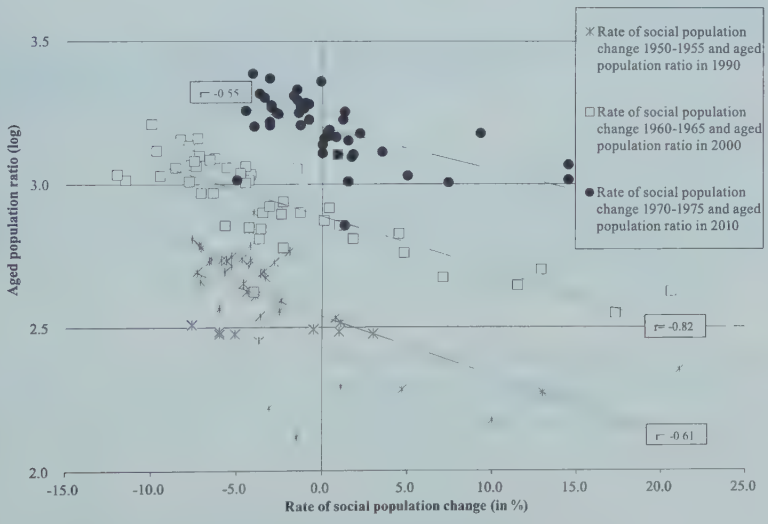
[8] As closer inspection of Figure 4.12 reveals, Akita has a slightly lower crude birth rate than Tokyo and Shimane. On the other hand, the two rural prefectures have a higher total fertility rate (Shimane 1.7 and Akita 1.3) than Tokyo (1.1). Taken together, these figures indicate that while women of childbearing age in Shimane and Akita on average have more children than women in Tokyo, there are proportionately fewer women of childbearing age in the two rural prefectures.

Figure 4.13 Migration and aged population ratio 40 years later

(a) Pre-war period



(b) Post-war period



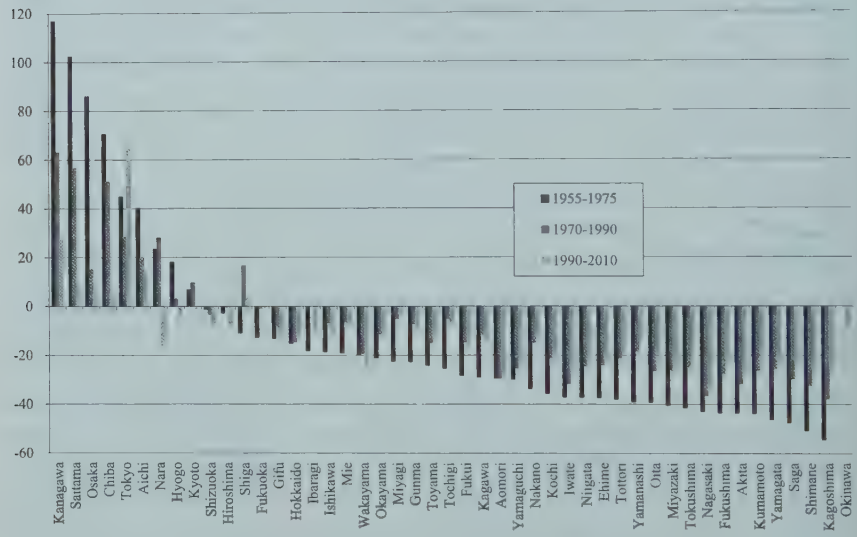
Source: *Population Census* (various issues), Statistics Bureau, MIC.

Table 4.3 Correlation coefficient between the log of labor productivity relative to the national average and the net in-migration rate of each cohort in the 20 years from age 10–14 to age 30–34

	1955–1975	1970–1990	1990–2008
Correlation coefficient	0.628	0.750	0.710

Note: Okinawa is not included in the calculation for 1955–75 and 1970–90.
Sources: R-JIP Database 2013 and *Population Census* (various issues), Statistics Bureau, MIC.

Figure 4.14 Net migration rate of each cohort in the 20 years from age 10–14 to age 30–34 by prefecture (in %)



Sources: *Population Census* (various issues), Statistics Bureau, MIC.

migration from lagging, rural prefectures and in-migration in leading, urban prefectures generally peaked in the period 1955–1970 and slowed substantially in the subsequent subperiods. At least two reasons for this slowdown in migration can be identified. The first is that with the aging of Japan's population overall, the percentage of the population at an age when individuals are most likely to migrate, i.e., those in their teens and twenties, has been declining. The second is that income disparities across prefectures—the main engine of migration—have gradually declined.

In order to confirm that not only the first factor but also the second factor has been responsible for the slowdown of migration in recent years, we measured the net migration rate of each cohort from when they are aged 10–14 to when they are aged 30–34 for each prefecture. For example, to derive the 20-year net migration rate of the cohort that was aged 10–14 in 1955, we used the following equation:

Net in-migration rate of prefecture r from 1955 to 1975 =
{(Population of 30–34 year olds in prefecture r in 1975) −
(Population of 10–14 year olds in prefecture r in 1975) × (National average survival rate of this cohort from 1955 to 1975)} / (Population of 10–14 year olds in prefecture r in 1975).

Figure 4.14 shows the result. Prefectures are ordered in terms of their net in-migration rate from 1955 to 1975. The figure shows that young cohorts migrated from low income prefectures to high income prefectures. However, the rate of net migration of these cohorts declined substantially over time. For example, while the net rate of in-migration for Kanagawa during the period 1955–1975 was almost 120% (i.e., the size of that cohort more than doubled as a result of in-migration), this slowed to less than 30% during the period 1990–2010. Conversely, while the net out-migration rate for Kagoshima was more than 50% during 1955–1975, this halved to around 25% in 1990–2010. These changes closely reflect the substantial decline in income disparities: whereas in 1955, the per capita GPP of Kanagawa was 2.38 times that of Kagoshima, by 1970, this had fallen to a factor of 1.31, and by 2008 to a factor of 1.06. Thus, as regional income disparities declined, younger generations in low income prefectures had less incentive to move to high income prefectures.[9]

Next, let us examine the implications of the trends discussed so far for regional inequality. Differences in demographic age structure as a result of migration potentially affect prefectural per capita GPP in a number of ways. One of these is the impact on labor force participa-

[9] Another likely explanation is that the decline of the birth rate created many one-child families and children of such families tended to stay with their parents. This change may also have contributed to reducing out-migration from low income regions.

tion and hence the share of the gainfully occupied population. Figure 4.6 above showed that from 1955 to around 1990, the share of the occupied population in the leading prefectures increased considerably, rising well above that in the lagging prefectures. Tables 4.1 and 4.2 showed that, as a result, differences in the occupied population share during this period contributed to divergence in per capita GPP, and it was suggested that such differences in the occupied population share reflected the impact of migration on prefectures' demographic age structures. To examine the link between age structure and per capita GPP more closely, Figure 4.15 plots prefectures' per capita GPP relative to the national average (in log) on the vertical axis and prefectures' age population ratio (also in log) on the horizontal axis for four different benchmark years. The figure shows that especially from 1970 onward, there is a clear negative relationship between the two: that is, prefectures with a higher aged population ratio tend to have a lower per capita GPP.

Apart from differences in the occupied population share, the negative relationship seen in Figure 4.15, however, also reflects differences in labor productivity. As can be seen in Figure 4.16, which plots prefectures' labor productivity relative to the national average (in log) on the vertical axis and prefectures' age population ratio (also in log) on the horizontal axis, these are also negatively related in all four benchmark years. In other words, prefectures with a higher aged population ratio tend to have lower labor productivity. The direction of causality underlying this negative relationship—that is, whether a higher aged population ratio leads to lower labor productivity, or whether prefectures with lower labor productivity experienced higher out-migration in the past and therefore ended up having a higher aged population ratio—is not immediately clear.

In order to examine this, we start by decomposing labor productivity differences across prefectures into differences in the TFP level, differences in capital intensity, and differences in labor quality, following Caves, Christensen, and Diewert (1982):

$$\ln\left(\frac{y_r}{\bar{y}}\right) = RTFP_r + \frac{1}{2}(\theta_r^K + \bar{\theta}^K)\left\{\ln\left(\frac{Z_r}{\bar{Z}}\right) - \ln\left(\frac{H_r}{\bar{H}}\right)\right\} + \frac{1}{2}(\theta_r^L + \bar{\theta}^L)\ln\left(\frac{q_r}{\bar{q}}\right), \tag{4.7}$$

Figure 4.15 Aged population ratio and per capita GPP

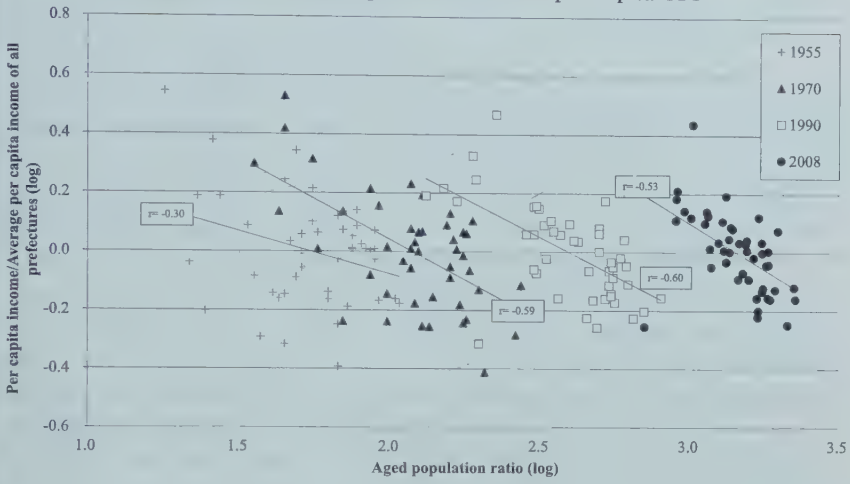
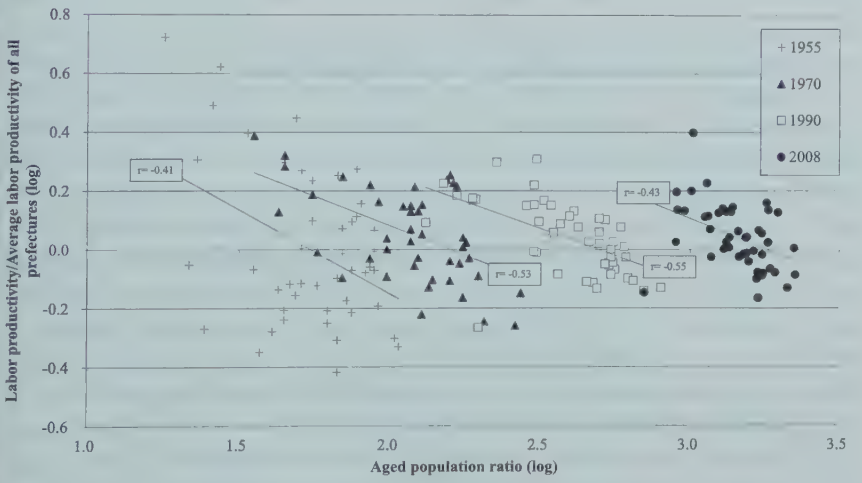


Figure 4.16 Aged population ratio and labor productivity



where y_r, Z_r, H_r, q_r, and $RTFP_r$ denote nominal value added per hour, capital stock, man-hour labor input, labor quality, and the relative TFP level of prefecture r. θ_r^K and θ_r^L denote the capital and labor cost shares in prefecture r. Variables with an upper bar denote the geo-

Table 4.4 Decomposition of the link between the aged population ratio and labor productivity

	1955	1970	1990	2008
Covariance between log of aged population ratio and log of labor productivity relative to national average	−0.020 (100.0)	−0.017 (100.0)	−0.012 (100.0)	−0.005 (100.0)
Covariance between log of aged population ratio and log of relative TFP level	−0.015 (74.9)	−0.007 (39.8)	−0.007 (56.3)	−0.003 (55.3)
Covariance between log of aged population ratio and contribution of relative capital-labor ratio to labor productivity gap	−0.003 (13.8)	−0.008 (45.4)	−0.003 (21.8)	−0.001 (21.5)
Covariance between log of aged population ratio and contribution of relative labor quality to labor productivity gap	−0.002 (11.3)	−0.003 (14.8)	−0.003 (21.8)	−0.001 (23.1)

Notes: The table shows the results of decomposing the covariance between the log of the aged population ratio and the log of labor productivity relative to the national average as well as the contribution of each factor (percentage contribution in parentheses).
Sources: R-JIP Database 2013 and *Population Census* (various issues), Statistics Bureau, MIC.

metric mean of that variable across prefectures.

Using the above equation, the covariance between the log of the aged population ratio and the log of labor productivity relative to the national average can be decomposed into (1) the covariance between the log of the aged population ratio and the log of the relative TFP level (the first term on the right-hand side of the above equation), (2) the covariance between the log of the aged population ratio and the contribution of the relative capital-labor ratio to the labor productivity gap (the second term on the right-hand side of the above equation), and (3) the covariance between the log of the aged population ratio and the contribution of relative labor quality to the labor productivity gap (the third term on the right-hand side of the above equation).

Table 4.4 presenting the results of this decomposition shows that the covariance between the log of the aged population ratio and all three factors underlying labor productivity differences—TFP, the capital-labor ratio, and labor quality—is always negative. Moreover, the correlation coefficients are all statistically significant at the 5% level except in two cases: the correlation with the capital-labor ratio in 1955 and 2008. We can thus say that all three factors contributed to

the lower labor productivity in prefectures with a larger aged population ratio.

However, among the three factors, TFP differences made the largest contribution in 1955, 1990, and 2008. In other words, labor productivity in aged prefectures is relatively low mainly because of their low TFP, and plotting prefectures' relative TFP level against their aged population ratio yields patterns that look very similar to those in Figures 4.15 and 4.16, although the correlation coefficients are somewhat lower, ranging from −0.32 for 2008 to −0.50 for 1990.[10]

Having identified TFP as the most important factor in determining the relationship between prefectures' demographic age structure and labor productivity, we can now examine the direction of causality underlying this relationship. One possible explanation of that relationship is that as the aged population share in a prefecture rises, the share of industries such as care for the elderly and medical services, which have comparatively low TFP growth rates, increases, thus reducing aggregate TFP growth in the prefecture. However, examining the correlation between the aged population ratio in 1955, 1970, and 1990 and TFP growth in the succeeding two decades shows that this is not statistically significant for 1970–1990 and 1990–2008 and even significantly positive for 1955–1975. These results suggest that population aging does not reduce TFP growth. Similarly, we examined whether there is a statistically significant negative correlation between the change of the aged population ratio and the change of the TFP level in each period, i.e., 1955–1975, 1970–1990, and 1990–2008, but we found no such relationship. These results suggest that population aging does not systematically lower prefectures' relative TFP level.

We therefore next consider the possibility that the causality is the reverse; namely, that if a lower TFP level means lower wage rates and out-migration of the younger generation, prefectures with a high aged population ratio today may have had low TFP levels 30–40 years ago, so if TFP differences across prefectures are persistent over time (prefectures with a low relative TFP level continue to have a low relative TFP level), we will observe a negative current correlation of the TFP level and the aged population ratio.

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[10] The results are not shown to conserve space, but are available from the authors on request.

Table 4.5 Intertemporal correlation coefficient of relative TPF level

	1955	1970	1990
1970	0.61		
1990	0.60	0.68	
2008	0.63	0.53	0.65

Note: Okinawa is not-included in the analysis.
Source: R-JIP Database 2013.

Table 4.6 Standard deviation of relative TFP: 1955–2008

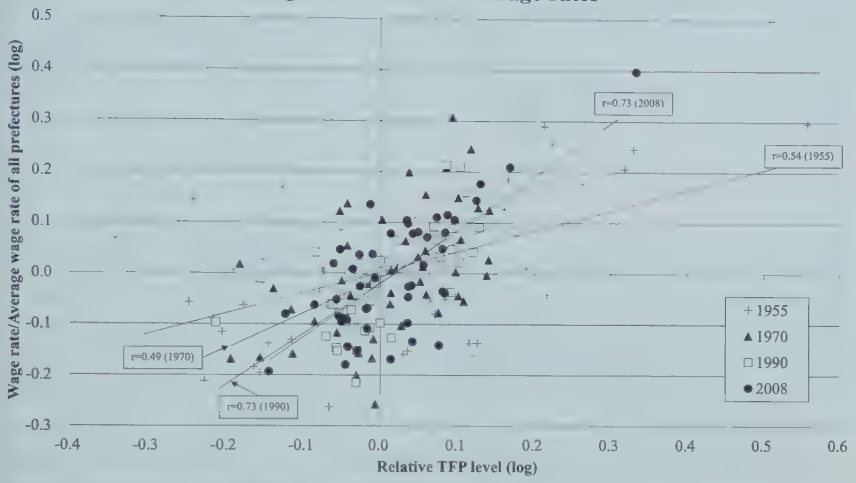
1955	1970	1990	2008
0.18	0.09	0.08	0.08

Note: Okinawa is not included in the calculations for 1955 and 1970.
Source: R-JIP Database 2013.

Table 4.5 shows the intertemporal correlation coefficient of prefectures' relative TFP level. All the coefficients are statistically significant at the 5% level, indicating that TFP differences across prefectures are quite stable over time. Moreover, Table 4.6 shows the standard deviation of the relative TFP level (log) across prefectures. We find that while TFP differences across prefectures declined substantially from 1955 to 1970, they remained more or less unchanged after that. Given that firms invest across all regions and major corporations have networks of affiliates throughout Japan, it seems unlikely that this persistence in TFP differences is due to slow technology diffusion. Instead, the persistence in TFP gaps is due other factors. One of these is agglomeration effects. High income regions enjoy positive agglomeration effects in certain industries or with regard to the population overall. And since firms and households are attracted by such positive effects, agglomeration persists. Another possible factor is locational advantages as a result of natural or policy factors. For instance, a prefecture with a good sea port may enjoy higher TFP for a long period.

Having shown that TFP differences across prefectures are quite persistent, the next step is to examine the link between TFP differences and wages. This is done in Figure 4.17, which shows the cross-prefectural relationship between relative TFP levels and wage rates. It should be noted that when we measure wage rates, differences in

Figure 4.17 TFP and wage rates



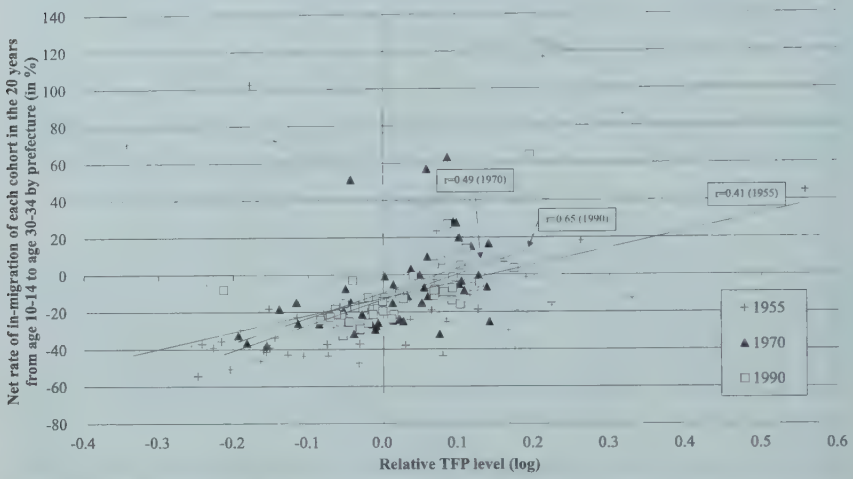
Sources: R-JIP Database 2013 and *Monthly Labour Survey (Prefectural Survey)*. Ministry of Health, Labour and Welfare.

labor quality are not taken into account, so that there is a risk that we may overestimate the wage rates of high income prefectures, since—as seen in the previous sections—such prefectures tend to have higher labor quality. We find that there is a statistically significant (at the 5% level) positive correlation between TFP levels and wage rates.

Finally, to examine whether lower TFP levels caused the out-migration of the young, in Figure 4.18 we compare each prefecture's relative TFP level in 1955, 1970, and 1990 and the out-migration of the young in the periods 1955–1975, 1970–1990, and 1990–2010, respectively. Like for Figure 4.14, we measure migration of the young in terms of the net migration rates of a cohort from when they are aged 10–14 to when they are aged 30–34. We find that the correlation is positive and statistically significant (at the 5% level) for all three sub-periods.

Thus, what we find is that population aging does not systematically reduce prefectural TFP levels. Instead, it is more plausible that causality runs in the opposite direction. That is, a low TFP level means a low wage rate and out-migration of the young. Most prefectures that have a high aged population ratio today had a low TFP level 30–40 years ago. And since TFP differences across prefectures

Figure 4.18 TFP and the net migration rate of each cohort in the 20 years from age 10–14 to age 30–34 by prefecture



Sources: R-JIP Database 2013 and *Population Census* (various issues), Statistics Bureau, MIC.

are persistent over time, we observe a negative correlation between current TFP and labor productivity levels and current aged population ratios.

Summing up, focusing on the impact of migration on prefectures' demographic age structure, we find that migration has had long-lasting effects on regional inequality. Given that it is mainly the young—those in their teens and twenties—that migrate, migration slowed down demographic aging in the receiving prefectures and accelerated it in the sending prefectures, with the result that the latter over the last three or four decades have come to have considerably higher aged population ratios than the former. This in turn means that, during the post-war period, the occupied population share in sending prefectures has been lower than that in receiving prefectures, contributing to the lower per capita GPP in those prefectures.

On the other hand, although a clear negative relationship between prefectures' aged population ratio and their labor productivity and TFP levels can be observed, our analysis does not find any evidence to suggest that out-migration caused lagging prefectures to have lower TFP. Rather, it appears that prefectures with relatively low TFP

today also had relatively low TFP three or four decades ago, giving rise to out-migration then, and this explains the observed correlation between the aged labor ratio and TFP today. This finding suggests that migration did not exacerbate productivity differences through its effects on prefectures' demographic age structure.

4.6 Conclusion

Reflecting the length of the period covered in our analysis—spanning more than 130 years—it is perhaps not surprising that it encompasses economic and social changes on an almost monumental scale. One of these changes is the large-scale redistribution of Japan's population from rural to urban areas concentrated along the Pacific coast, particularly the Tokyo-Osaka corridor. This shift in the population has shaped, and was shaped by, a similar pattern of geographic concentration of economic activity.

In the process, income inequality across prefectures first increased slightly during the pre-war period and then fell considerably and more or less steadily during the post-war period. During both of these phases, migration generally worked in the direction of convergence. Specifically, during the pre-war period, migration made a substantial contribution to convergence or considerably offset divergence due to other factors during all subperiods we have data for (1890-1940), while in the post-war period, migration made a large contribution to convergence during the high-speed growth era from 1955 to 1970.

What is more, the effects of migration on convergence were not offset by a "brain drain" from poorer to richer prefectures. Although migration did result in a reduction in the *quantity* of human capital in poorer prefectures and an increase in richer prefectures, the same cannot be said with regard to the *quality* of human capital stock. That is, there is no evidence of a systematic pattern whereby labor quality in poorer prefectures was lower than it would have been in the absence of migration and vice versa. In fact, in the case of Osaka, the evidence suggests that the quality of human capital was in fact lower than it would have been in the absence of in-migration, indicating that Osaka received a lot of less educated migrants.

On the other hand, migration did have a substantial impact on

prefectures' demographic age structure. In other words, prefectures that experienced substantial out-migration in the past have a considerably higher aged population ratio than prefectures that experienced substantial in-migration. In terms of regional inequality, this means that "older" prefectures have a lower per capita GPP because of a lower occupied population share. In addition, we found that "older" prefectures also had lower labor productivity and that the main reason for this were differences in TFP. However, our analysis suggests that the link between the aged population ratio and TFP does not reflect a causal relationship from the aged population ratio to TFP, but rather that prefectures with low relative TFP today already had low relative TFP in the past, resulting in out-migration in the past, which explains the correlation between the aged population ratio and TFP today.

In other words, the correlation reflects the persistence in TFP differences over time, and in this context it is interesting to relate our findings to a study by Davis and Weinstein (2002) focusing on the distribution of economic activity in Japan over a period of 8,000 years to examine three competing theoretical explanations: increasing returns, random growth, and locational fundamentals. Their analysis suggests that the distribution of economic activity in Japan can be explained by a hybrid theory combining locational fundamentals and increasing returns. Our findings in this chapter and in Chapter 2 support this conclusion. That is, the persistence in the relative position of prefectures in the distribution of economic activity as indicated by the rank order correlation in Chapter 2 and prefectures' share in national GDP in this chapter suggests that locational fundamentals and increasing returns—that is, agglomeration effects—have played an important role in shaping the regional pattern of economic activity in Japan. Specifically, prefectures that have more or less consistently seen out-migration and a decrease in their share in national output are those that are geographically remote from the heartland of economic activity, suggesting that locational fundamentals and agglomeration effects have mutually reinforced each other, and this can be seen in the persistence of TFP differences over time.

APPENDIX: Construction of migration series at the prefecture level

This appendix describes the procedure we employ for constructing migration series at the prefecture level. The first Japanese population census was carried out in 1920. We can obtain reliable figures on population and migration from that date onward,[11] but there is no consensus on population estimates for earlier years. We therefore have to rely on figures based on family registration (*koseki* in Japanese) constructed by governmental authorities each year before 1897 and every five years between 1898 and 1918. Households were required to declare life-cycle events such as birth, marriage, death, and migration, to civil officers. But it is well known that registration was often delayed and in some cases never occurred.[12] Estimates on migration are affected by such errors and omissions, as evidenced by inconsistencies between the total national-level in- and out-migration. In an attempt to measure actual residential populations, the government instructed people moving from their official place of residence in which they were registered (*honseki chi*) to other places in Japan (or abroad) for more than 90 days to submit a registration for out-migration (*de-kiryu todoke*) to the local administration in the place of origin and an in-migration registration (*iri-kiryu todoke*) in the place of destination.[13] In principle, after adjustment for international flows, the total number of in- and out-migrants across regions in Japan

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[11] Prefecture-level figures for the period from 1920 to 1940 are reported in Japan Statistical Association (2006), Table 2-6: Natural Increase and Net Migration of Population—Prefectures (1920-2000).

[12] For example, in the early Meiji era, parents may have "skipped" both birth and death registration in the case of infant death. According to Takase (1991), this situation improved after 1884, since when death certification was required to cremate a body.

[13] When people moved to yet another destinations, they had to apply for a transfer of their registration (*ten-kiryu todoke*), effectively cancelling the registration at the first destination, and submit a new in-migration registration at the new destination. Details of this registration system are explained in Umemura, Takamatsu, and Itoh (1983: 52-54) and Saito (1973).

should be the same; however, in practice, the number of in-migrants exceeded the number of out-migrants by 1.7 million in 1898, 1.9 million in 1903, 2.4 million in 1908, 2.2 million in 1913, and 2.4 million in 1918.[14] Moreover, another problem is the modification of migration accounts (*kiryu seiri*), which should be taken into account. Local governments, especially in urban areas, were aware of these discrepancies and modified their migration accounts to grasp the exact current residential population in their region. This resulted in discontinuities in urban population time series.

Takahashi and Nakagawa (2010) have attempted to estimate net migration flows, that is, the social growth in the population of each prefecture in Japan before 1920 using the following approach:

$$\Delta P_s = \Delta P_{res} - \Delta P_{reg},$$

where ΔP_s is the social population growth in the prefecture, ΔP_{res} is the change in the current residential population in the prefecture, and ΔP_{reg} is the change in the registered population in the prefecture.

The crucial assumption of this estimation is that the difference in the number of birth and death registrations, that is, the increase in the population that has its family registry in a particular prefecture (*honseki chi jinko*) can be regarded as the natural increase in the population of that prefecture.[15] If we subtract their estimates from the current residential population (*genju jinko*) in each prefecture, we can obtain figures of net migration. Takahashi and Nakagawa (2010) made adjustments for discontinuities, although not for the case of Tokyo in 1908–1909. Residential population estimates for Tokyo using the methodology presented in Appendix 2 are used to generate figures of net migration for this prefecture.

[14] Umemura, Takamatsu, and Itoh (1983: 54).

[15] However, this assumption is problematic, since it was not uncommon for people not to change their place of family registration (*honseki chi*) even after moving permanently to another place.

Chapter 5

Regional Factor Inputs and Convergence in Japan: A Macro-Level Analysis, 1955-2008

5.1 Introduction

As seen in the preceding chapters, prefectural inequality in income and labor productivity in Japan peaked in the first half of the 19th century and declined rapidly after World War II. The aim of the present chapter is to more closely examine these trends in the post-war period, for which it is possible to obtain prefecture-level estimates of capital stock and labor quality. Such data allow us to analyze in detail the decline in differences in labor productivity from the supply-side. Specifically, we examine the 53-year period stretching from 1955, the first year for which the *Prefectural Accounts* are available, to 2008, the most recent year for which data on prefectural capital stock are currently available.[1] It should be noted that the data that we use here are for prefectures as a whole; that is, for the total of all industries. However, for the period from 1970 onward, it is possible to estimate labor productivity and total factor productivity disaggregated into 23 industries. An even more detailed analysis of economic convergence

[1] The research of this chapter was conducted as part of the project "Regional-Level Japan Industrial Productivity Database: Database Refinement and Its Analysis" at the Research Institute of Economy, Trade and Industry (RIETI).

using these data by industry for the shorter period from 1970 to 2008 is provided in Chapter 6.

Let us start by providing a simple explanation of the analytical framework employed in this chapter. Assuming a neoclassical production function with constant returns to scale, labor productivity in prefecture r, denoted by Y_r/H_r (real value added per man-hour), depends on the capital stock per man-hour in that prefecture, Z_r/H_r (which we will refer to as the capital-labor ratio),[2] on labor quality, q_r, and on total factor productivity (TFP), A_r:

$$\frac{Y_r}{H_r}=F\left(\frac{Z_r}{H_r}, q_r, A_r\right). \tag{5.1}$$

As argued in Chapter 4, if prefectural differences in capital input and TFP remain unchanged, the movement of labor from prefectures with high labor productivity to prefectures with low labor productivity reduces prefectural differences in labor productivity, and Chapter 4 examined the role of the movement of labor over the extremely long period from 1874 to 2008. However, as equation (5.1) shows, differences in labor productivity across prefectures also depend on the capital-labor ratio as well as TFP and labor quality, something that we could not take into account in Chapter 4 due to the lack of necessary data. Against this background, the purpose of this chapter, focusing on the period from 1955, is to estimate prefectural capital input, labor quality, and TFP and to examine how differences in these affected

[2] In this context, it should be noted that there is considerable heterogeneity in capital assets. Some capital assets have relatively high user costs (unit costs for the use of a capital asset for one period), because they depreciate rapidly and prices fall due to technical progress (information and communications equipment is an example), while other capital assets (such as structures) have comparatively low user costs due to low rates of depreciation. The fact that firms use both types of capital assets in production means that the higher the user cost of a capital asset, the higher the marginal product (capital service) of that capital asset is likely to be. Given these considerations, it has become common in growth accounting analyses to take differences in user costs across capital assets into account and estimate the capital service input. Unfortunately, however, because the necessary data are not available, we have been unable to prepare prefectural capital stock data by type of capital assets, so that in this chapter we measure capital service input using the total value of real capital stock.

prefectural differences in labor productivity.[3] A detailed description of how these data are estimated is provided in Appendix 3 at the end of the volume.

The remainder of this chapter is organized as follows. In the next section (Section 5.2), we decompose prefectural differences in labor productivity from a cross-sectional perspective for the first and the last year of our observation period (1955 and 2008) into differences in the capital-labor ratio, differences in labor quality, and differences in TFP. This kind of analysis is called level accounting and has been used in numerous studies, including Hall and Jones (1999), Easterly and Levine (2001), and Inklaar and Timmer (2008), for the comparison of labor productivity differences across countries. These studies indicate that the main reason for differences in labor productivity across countries is differences in TFP. What is more, the finding that the largest part of labor productivity differences across countries is due to TFP differences applies not only to differences between developed and developing countries, but also to differences among advanced countries. For instance, using Inklaar and Timmer's (2008) data, Fukao (2012) compared (price-adjusted) labor productivity in the European Union (using the average of the EU15), Japan, and the United States in 2005 using the United States as the reference point. He found that labor productivity in the EU15 was 25% lower and in Japan 42% lower than in the United States, with TFP accounting for 14 and 44 percentage points respectively. Although one would expect TFP differences across regions within a particular country to be smaller than across countries, differences in capital-labor ratios are also likely to be smaller. Thus, a priori there is no reason to expect one or the other to make a larger contribution to regional labor productivity differences. We examine this issue in the next section. Moreover,

[3] In this context, it should be noted that as a result of the expansion of major metropolises such as Tokyo and Osaka during the postwar period, commuting from surrounding prefectures such as Saitama and Nara increased. Given that the GPP data in the *Prefectural Accounts* are for output within each prefecture, this means that when examining equation (5.1), it is necessary to measure labor input not on a residence basis but on the basis of where people work. In the analysis in this and the next chapter, our data are adjusted to take this into account.

we examine what the reasons for the observed decline in labor productivity differences between 1955 and 2008 are.

Section 5.3, using growth accounting, then examines the mechanisms that brought about the decline in regional inequality during the post-war period. As indicated in the literature review in Chapter 1, there are a large number of empirical studies focusing on economic convergence during the postwar period, ranging from Barro and Sala-i-Martin (1991), who initiated this kind of study, to more recent studies, such as Montresor, Pecci, and Pontarollo (2012) on regional labor productivity differences within the EU. Studies on regional convergence in Japan include those by Barro and Sala-i-Martin (1992b) and Shioji (2001), but although these produce interesting results, they do not estimate prefectural capital stocks and therefore treat convergence as a "black box"—that is, they have little to say about the mechanisms underlying convergence. Against this background, Section 5.3 seeks to quantitatively examine the mechanisms driving convergence. Our results indicate that the reduction in regional differences in both TFP and capital-labor ratios played a substantial role.

The capital-labor ratio in a particular prefecture increases if either labor moves out of the prefecture or capital accumulation continues. In Chapter 4, we examined the impact of the movement of labor through internal migration on prefectural income inequality. Comparing top and bottom income prefectures in terms of per capita GPP, we found that migration from poorer to richer prefectures more or less consistently contributed to a reduction in prefectural income inequality from the start of the Meiji era until the present. Moreover, we found that from 1970 onward, capital stock in poorer prefectures grew at a faster rate than in richer prefectures and this further contributed to the reduction in prefectural income inequality. Finally, we found that for the post-war period, for which data are available, no brain drain—that is, that it is in particular well-educated workers that tended to migrate from poorer to richer prefectures—could be observed.

Taking advantage of the wider range of prefectural data available for the post-war period, Section 5.4 examines the role of factor movements in greater detail, thus complementing the analysis in Chapter 4. Specifically, by looking at the relationship between per capita GPP at the start of the period and the subsequent average capital stock and

TFP growth, we examine how capital accumulation and TFP growth contributed to the decline in per capita GPP differences between 1955 and 2008. Next, we examine whether prefectures with higher rates of growth in capital stock have higher saving rates or whether, alternatively, they registered capital inflows. Finally, we examine what caused the decrease in prefectural TFP differences. Section 5.5 summarizes and discusses the results obtained in this chapter.

5.2 Sources of prefectural differences in labor productivity: Cross-section analysis

In this section, we examine the causes of prefectural differences in labor productivity. Following Caves, Christensen, and Diewert (1982) and Tokui, Makino, Fukao, et al. (2013), we decompose cross-section prefectural differences in labor productivity into differences in the capital-labor ratio, differences in labor quality, and differences in TFP. To some extent, the analysis shares similarities with that of Tokui, Makino, Fukao, et al. (2013), who conduct a similar exercise using the Regional-Level Japan Industrial Productivity (R-JIP) Database, which provides data on economic activity and factor inputs for each prefecture broken down into 23 industries for the period 1970-2008. However, our aim here is to focus on the entire post-war period from 1955 onward, which means that we have prefectural capital stock and other data only at the aggregate level, that is, for the total of all industries. That being said, in Chapter 6, we use disaggregated industry data from the R-JIP Database from 1970 onward to examine regional convergence in even more detail.

Let us start by explaining our decomposition approach. Prefectures are indexed by r ($=1, 2, \ldots, 47$). Since Okinawa was returned to Japan by United States only in 1972, we use data for 46 prefectures until then. Prefecture r's nominal value added is denoted by Y_r, real capital stock by Z_r, man-hours by H_r, labor quality by q_r (obtained by dividing a labor input index by man-hours), the cost share of capital by θ_r^K and the cost share of labor by θ_r^L ($=1-\theta_r^K$). Because this is a cross-section analysis, we omit the time subscript.

The national averages of value added, real capital stock, man-hours, and labor quality are defined by the following equations:

$$\ln\bar{Y}=\frac{1}{47}\sum_{r=1}^{47}\ln Y_r,\ \ln\bar{Z}=\frac{1}{47}\sum_{r=1}^{47}\ln Z_r,$$

$$\ln\bar{H}=\frac{1}{47}\sum_{r=1}^{47}\ln H_r,\ \ln\bar{q}=\frac{1}{47}\sum_{r=1}^{47}\ln q_r.$$

Moreover, the national averages of the cost shares of capital and labor are defined by the following equations:

$$\bar{\theta}^K=\frac{1}{47}\sum_{r=1}^{47}\theta_r^K,\ \bar{\theta}^L=\frac{1}{47}\sum_{r=1}^{47}\theta_r^L.$$

Prefectures' relative TFP, $RTFP_r$, is then defined as follows:

$$RTFP_r=\ln\left(\frac{Y_r}{\bar{Y}}\right)-\frac{1}{2}(\theta_r^K+\bar{\theta}^K)\ln\left(\frac{Z_r}{\bar{Z}}\right)-\frac{1}{2}(\theta_r^L+\bar{\theta}^L)\ln\left(\frac{q_r}{\bar{q}}\frac{H_r}{\bar{H}}\right). \quad (5.2)$$

As mentioned previously, this cross-sectional definition of the relative productivity level follows Caves, Christensen, and Diewert (1982). While they do not refer to this as TFP, the two are closely related, and following the literature, we will refer to this as TFP here.

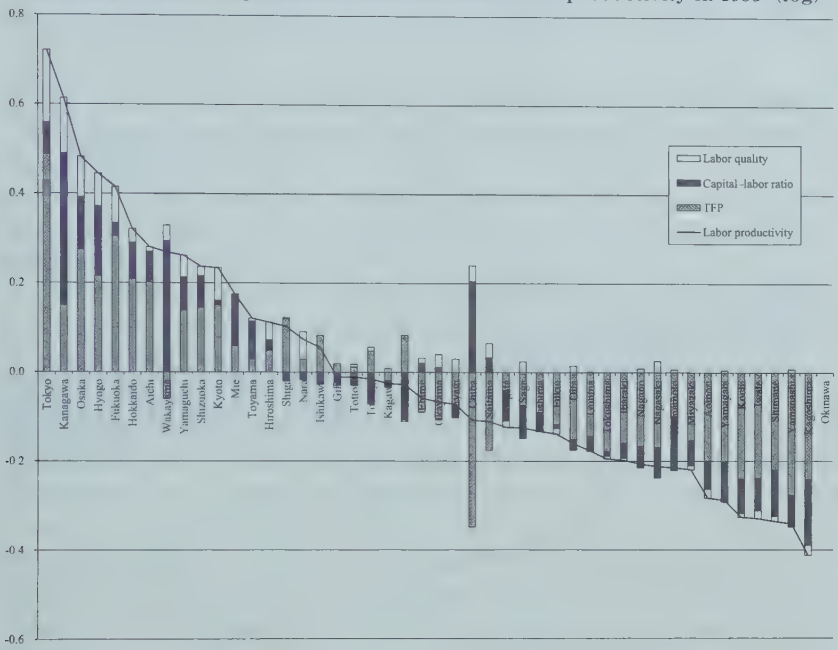
Using the fact that $\theta_r^L=1-\theta_r^K$, the equation above can be transformed to obtain the following:

$$\ln\left(\frac{Y_r}{\bar{Y}}\right)-\ln\left(\frac{H_r}{\bar{H}}\right)=RTFP_r+\frac{1}{2}(\theta_r^K+\bar{\theta}^K)\left\{\ln\left(\frac{Z_r}{\bar{Z}}\right)-\ln\left(\frac{H_r}{\bar{H}}\right)\right\}+\frac{1}{2}(\theta_r^L+\bar{\theta}^L)\ln\left(\frac{q_r^L}{\bar{q}}\right). \quad (5.3)$$

Equation (5.3) shows that the divergence of each prefecture's labor productivity from the national average can be decomposed into the part caused by differences in TFP, that caused by differences in the capital-labor ratio, and that caused by differences in labor quality. The results of employing this kind of level accounting using equation (5.3) for 1955, the starting point of our data, are shown in Figure 5.1.

The level accounting analysis for 1955 suggests the following. The prefecture with the highest labor productivity in 1955 was Tokyo, whose labor productivity was 72.1% above the national average. On the other hand, the prefecture with the lowest labor productivity was Kagoshima, with a level 41.2% below the national average, so that the difference between the two amounted to about 113 percentage points.

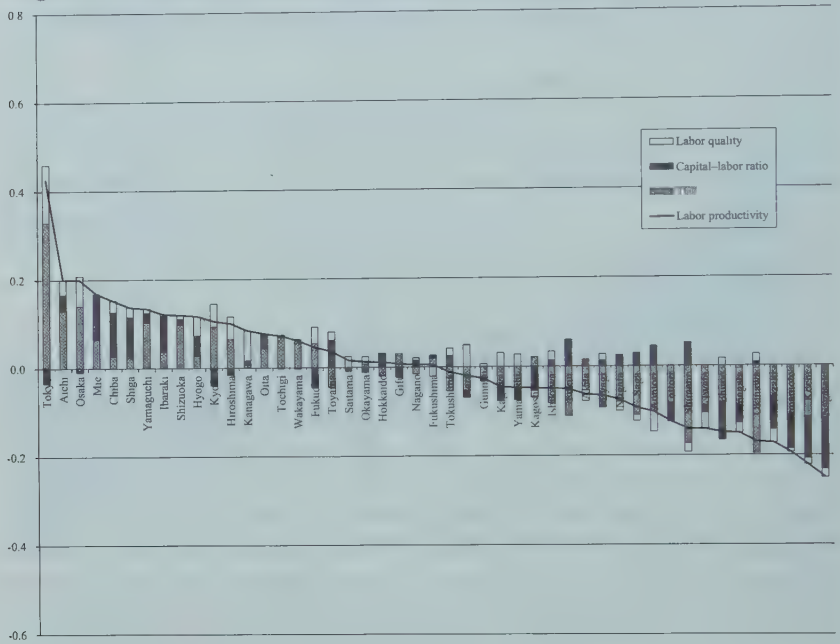
Figure 5.1 Causes of prefectural differences in labor productivity in 1955 (log)



Most of this gap was due to the difference in TFP between the two prefectures: while Tokyo's TFP was 48.8% above the national average, that of Kagoshima was 24.1% below the national average, for a difference of about 73 percentage points. In other words, TFP accounted for almost two thirds (73/113=0.646) of the difference in labor productivity between the top and the bottom prefecture.

Further, in most prefectures, TFP accounted for most of the divergence of labor productivity from the national average, although there are some notable exceptions (Kanagawa, Wakayama, and Chiba). This means that the contribution of differences in the capital-labor ratio was smaller than that of differences in TFP. However, a notable pattern that emerges is that, generally speaking, in prefectures with above-average labor productivity the capital-labor ratio made a positive contribution and in prefectures with below-average labor productivity it made a negative contribution to the labor productivity gap vis-à-vis the national average, although there are again

Figure 5.2 Causes of prefectural differences in labor productivity in 2008 (log)



some exceptions such as Chiba.

Finally, differences in labor quality made a much smaller contribution to labor productivity differences than TFP or capital-labor ratios. In addition, although there is a tendency for labor quality to be higher in prefectures comprising a large city, for other prefectures it is difficult to discern a clear pattern in the contribution of labor quality.

Summing up, in 1955, differences in TFP, capital-labor ratios, and labor quality all contributed to differences in labor productivity and together gave rise to large prefectural differences in labor productivity. Further, differences in TFP made the largest contribution to labor productivity differences, followed by differences in capital-labor ratios. On the other hand, the contribution of labor quality differences was rather small.

Next, Figure 5.2 shows the results of level accounting for 2008, the last year in our dataset. The labor productivity difference in 2008 between the top prefecture (Tokyo, 42.6%) and the bottom prefec-

ture (Nagasaki, −25.1%) is 68 percentage points, which is considerably smaller than that in 1955. The main reason for this decline is the decline in the difference in TFP. Although labor productivity still tends to be higher in prefectures with high TFP, the difference in TFP between the top and the bottom prefecture had shrunk considerably: Tokyo's TFP was only 32.9% above the national average, while Nagasaki's was only 11.8% below the national average, so that the gap was about 45 percentage points. In other words, both the gap in labor productivity overall and in TFP had fallen by about two fifths.

Regarding the contribution of differences in the capital-labor ratio, the situation in 2008 was very different from that in 1955. Specifically, in many prefectures with above-average labor productivity, including Tokyo and Osaka, the contribution of the capital-labor ratio to relative labor productivity is actually negative, while among the 23 prefectures with below-average labor productivity, the contribution is positive in 10 prefectures (Tokushima, Ishikawa, Fukui, Akita, Miyagi, Niigata, Saga, Aomori, Shimane, and Okinawa). In other words, unlike in 1955, there no longer is a clear relationship between differences in the capital-labor ratio and differences in labor productivity. Finally, like in 1955, the contribution of differences in labor quality was not very large.

Next, in order to examine in more detail how differences in TFP, capital-labor ratios, and labor quality contributed to prefectural differences in labor productivity, we calculate the covariance between the three terms on the right-hand side of equation (5.3) and the log of prefectural relative labor productivity (i.e., the left-hand side of equation (5.3)) for certain years during our observation period. This allows us to decompose the dispersion of the log of prefectural relative labor productivity (the square root of which approximately corresponds to the coefficient of variation of prefectural differences in labor productivity) into the sum of the covariances between the log of prefectural relative labor productivity and the supply-side determinants of prefectural labor productivity differences. The results are shown in Table 5.1.

The factor decomposition of the dispersion of labor productivity yields similar results as Figures 5.1 and 5.2 regarding the mechanism underlying the reduction in prefectural labor productivity differences. That is, regardless of the year, TFP differences made the largest con-

Table 5.1 Factor decomposition of the dispersion in the log of prefectural relative labor productivity

	1955	1970	1990	2008
Dispersion of labor productivity differences	0.070	0.050	0.025	0.017
Contribution of TFP differences	0.042	0.025	0.014	0.011
Contribution of differences in capital-labor ratio	0.019	0.018	0.006	0.003
Contribution of differences in labor quality	0.008	0.007	0.004	0.003

tribution to differences in labor productivity, followed by differences in the capital-labor ratio, and then differences in labor quality, whose contribution has been small throughout. Moreover, differences in these three factors decreased over time, so that prefectural differences in labor productivity steadily declined.

However, looking at the changes over the 15–20 year intervals shown here, the main factor responsible for the reduction in labor productivity differences varies depending on the period in question. During the high-speed growth era from 1955 to 1970, the driving force of the decline in labor productivity differences was the decline in TFP differences, while differences in the capital-labor ratio and labor quality hardly declined at all. On the other hand, between 1970 and 1990, it was a decline in differences in the capital-labor ratio that made the largest contribution to the decline in labor productivity differences, although a decline in TFP differences and labor quality differences also played a role. Finally, from 1990 to 2008, differences in labor quality declined only marginally. Again it was the reduction in differences in TFP and the capital-labor ratio that made the largest contribution to falling labor productivity differences, but the extent of that reduction was much smaller than in 1970–1990.

Let us consider the reasons for the trends observed here. In the case of the decline in differences in the capital-labor ratio, this seems to be relatively straightforward to explain. During the high-speed growth era from 1955–1970, manufacturing activities to a considerable degree were concentrated in metropolitan areas. However, toward the end of that period—i.e., from the late 1960s—labor shortages as well as the introduction of environmental regulations meant that firms increasingly started to set up factories in rural areas. Since manufacturing sector activities tend to be more capital-intensive than non-manufacturing sector activities, this relocation reduced differences in

the capital-labor ratio. Moreover, it likely was the largest and most productive firms that relocated production to the countryside, so that advanced technology was diffused across Japan. This process therefore—at least in part—also explains the decline in TFP differences. Finally, as we shall show later, since 1955 the Japanese government has also substantially invested in social capital in rural parts of Japan. This policy likely further contributed to reducing productivity differences (on this issue, also see Fukao and Yue, 2000).

On the other hand, we are not entirely sure about the main engine of TFP convergence driving the decline in productivity differences from 1955 to 1970. As we have shown in Chapter 4, there was substantial migration from rural to urban prefectures during the high-speed growth era. Given that in the 1950s and 1960s agriculture still played a non-negligible role in the economy (as shown in Table 3.1, the output share in 1955 was 19%, falling to 6% in 1970), a possible reason therefore is that the departure of workers in rural prefectures increased the land-labor ratio in the agricultural sector in these prefectures, which in our data would be picked up as a TFP increase. Another possibility is that the TFP convergence reflects increases in social capital in lagging regions. Fukao and Yue (2000), for example, show that, during the period 1955-1973, rapid increases in social capital in rural regions contributed to the catching-up of these regions in labor productivity. It is, of course, possible, that the decline in TFP differences during this period is the result of a combination of factors, including the ones considered here as well as other, as yet unidentified, factors.

Next, let us compare our results with the results of level accounting analyses for the United States (Turner et al., 2010) and OECD countries (Caselli, 2005). In order to examine the proportion of cross-sectional variation in labor productivity accounted for by differences in physical and human capital intensity and differences in TFP, the studies employed the following framework. They assume the following production function in per-worker terms:

$$y_r = A_r y_{KHr},$$

where y_r denotes the gross value added per worker of region (or country) r, A_r denotes the TFP of r, and y_{KHr} denotes the contribution of physical and human capital per worker to labor productivity in

region r. Both studies do not take differences in working hours per worker across regions (or countries) into account and assume a Cobb-Douglas production function with a capital share of one third. In this case, y_{KHr} can be expressed by $k_r^{0.333}h_r^{0.666}$, where k and h denote the physical and human capital stock per worker in region (or country) r. Taking the variance of the log value of both sides of the above equation yields the following equation to decompose the variance in (the log of) labor productivity:

$$\mathrm{var}[\ln(y_r)]=\mathrm{var}[\ln(A_r)]+\mathrm{var}[\ln(y_{KHr})]+2\times\mathrm{cov}[\ln(A_r),\ln(y_{KHr})].$$

Turner et al. (2010) and Caselli (2005) use the ratio of the variance of inputs to the variance of output, $\mathrm{var}[\ln(y_{KHr})]/\mathrm{var}[\ln(y_r)]$, to measure the contribution of the variation in inputs to the variation in output.

In the case of our level accounting equation (5.3), the log values of y_r and y_{KHr} can be derived as follows:

$$\ln(y_r)=\ln\left(\frac{Y_r}{\bar{Y}}\right)-\ln\left(\frac{H_r}{\bar{H}}\right),$$

$$\ln(y_{KHr})=\frac{1}{2}(\theta_r^K+\bar{\theta}^K)\left\{\ln\left(\frac{Z_r}{\bar{Z}}\right)-\ln\left(\frac{H_r}{\bar{H}}\right)\right\}+\frac{1}{2}(\theta_r^L+\bar{\theta}^L)\ln\left(\frac{q_r}{\bar{q}}\right).$$

In contrast to Turner et al. (2010) and Caselli (2005), we have data on working hours at our disposal and measure both labor productivity and factor inputs per man-hour. Further, our level accounting differs from theirs in that we take regional differences in input cost shares into account.

Table 5.2 compares our results with those of the other two studies. Looking at the variance of labor productivity, $\mathrm{var}[\ln(y_r)]$, across regions, the values for Japan are comparable to those for the United States from 1920 onward. Moreover, both for Japan and the United States, the values steadily declined over time (except during the period 1840–1880 in the United States) and are much smaller than the corresponding value in the cross-country comparison across OECD countries. Thus, both Japan and the United States experienced a decrease in labor productivity differences across regions, and such regional differences are considerably smaller than differences across countries of a relatively similar level of economic development, indicating that convergence mechanisms—for the reasons highlighted in

Table 5.2 Level accounting across regions and countries

	Unit of observation	Year	var $[\ln(y_r)]$ a	var $[\ln(y_{KHr})]$ b	Contribution of inputs c = b/a
This study	Prefectures in Japan	1955	0.070	0.016	23%
		1970	0.050	0.016	32%
		1990	0.025	0.006	25%
		2008	0.017	0.003	20%
Turner et al. (2010)	States in the United States	1840	0.112	0.074	66%
		1880	0.184	0.065	35%
		1920	0.075	0.027	36%
		1960	0.027	0.008	31%
		2000	0.026	0.008	31%
Caselli (2005)	Countries	1996	1.297	0.500	39%
	OECD	1996	0.083	0.050	61%
	Non-OECD	1996	1.047	0.373	36%

Chapter 1—operate more smoothly across regions within countries than across countries.

Next, looking at the variance of inputs, var$[\ln(y_{KHr})]$, this remained the same in Japan from 1955 to 1970, indicating that other factors—namely, the decline in regional TFP differences—appear to have been the main engine of convergence during this period. This result is consistent with the findings of the factor decomposition shown in Table 5.1. However, after 1970, the variance in inputs declined and became very small even in comparison with the low level observed for the United States in 1960 and 2000. As a result of this decline, the contribution of variation in inputs to the variation in output in Japan fell after 1970 and became much smaller than in the United States and the OECD countries.

In sum, the level accounting results indicate that although differences in labor productivity across Japan's prefectures declined steadily from 1955, the main engine of that convergence changed over time. During the period 1955–1970, the main engine was convergence in TFP levels, while the degree of regional variation in input levels remained essentially unchanged. On the other hand, from 1970 onward, Japan experienced a strong convergence in regional input levels, so that the contribution of variation in inputs to variation in output steadily fell after 1970. Moreover, looking at the most recent year for

which data in each of the studies are available, we find that the variance of inputs in Japan was less than half of the US value and only about 6% of the variance across OECD countries.

5.3 Growth accounting

This section examines the mechanism driving convergence in prefectural labor productivity using growth accounting. Let us start by explaining our growth accounting approach. Define the TFP growth rate of prefecture r from year t to $t+\tau$, $\Delta \ln A_{r,t}$, as follows:

$$\Delta \ln A_{r,t} = \Delta \ln Y_{r,t} - \frac{1}{2}(\theta^{K}_{r,t+\tau} + \theta^{K}_{r,t}) \Delta \ln Z_{r,t} - \frac{1}{2}(\theta^{L}_{r,t+\tau} + \theta^{L}_{r,t}) \Delta \ln (q_{r,t} H_{r,t}), \tag{5.4}$$

where Δ represents the difference between year t and year $t+\tau$ in prefecture r's real value added, $Y_{r,t}$, capital stock, $Z_{r,t}$, man-hours, $H_{r,t}$, and labor quality, $q_{r,t}$, for year t. $\theta^{K}_{r,t}$ and $\theta^{L}_{r,t}$ respectively stand for the cost shares of capital and labor in prefecture r in year t, with the sum of the two equaling 1 for each year. It should be noted that because capital investment in equation (5.4) is measured simply as the total real capital stock and not as capital services taking into account differences in marginal productivity of capital across different types of capital stock, the contribution of improvements in the quality of capital to labor productivity are included in TFP increases. Next, rearranging equation (5.4) yields the following:

$$\Delta \ln Y_{r,t} - \Delta \ln H_{r,t} = \Delta \ln A_{r,t} + \frac{1}{2}(\theta^{K}_{r,t+\tau} + \theta^{K}_{r,t})(\Delta \ln Z_{r,t} - \Delta \ln H_{r,t}) + \frac{1}{2}(\theta^{L}_{r,t+\tau} + \theta^{L}_{r,t}) \Delta \ln q_{r,t}. \tag{5.5}$$

The left-hand side of equation (5.5) shows the growth rate of labor productivity in prefecture r from year t to year $t+\tau$, that is, the growth rate of real value added minus the growth rate of man-hours. Meanwhile, the terms on the right-hand side respectively show the contribution of TFP growth, the contribution of increases in the capital-labor ratio (real capital stock/man-hours), and the contribution of increases in labor quality to labor productivity growth.

Figure 5.3 Prefectural growth accounting: 1955–2008 (annual rates in %)

Note: TFP includes improvements in the quality of capital.

The results of this growth accounting for the period 1955–2008 are shown in Figure 5.3. Prefectures are arranged in descending order in terms of their labor productivity in 1955. The figure shows that, generally speaking, the higher a prefecture's labor productivity in 1955 was, the lower was its subsequent labor productivity growth, indicating that β-convergence took place. Looking at the factors contributing to labor productivity growth, we find that, generally speaking, the lower initial labor productivity was, the larger was the contribution of TFP growth and increases in the capital-labor ratio to labor productivity growth, so that these two factors contributed to the reduction of labor productivity differences. In contrast, in the case of labor quality, we find that the higher a prefecture's initial labor productivity was, the larger was the contribution of improvements in labor quality to labor productivity growth, so that labor quality worked in the direction of increasing differences in labor productivity.

In order to examine how each factor contributed to the reduction in labor productivity differences across prefectures, we decompose the

β-convergence coefficient following Fukao and Yue (2000). Specifically, we proceed as follows. Denoting the log difference on the left-hand side in equation (5.5) for prefecture r from year t to the next benchmark year $t+\tau$ by Gy_r and the three terms on the right-hand side by $GTFP_r$, Gz_r, and Gq_r, respectively, and, moreover, denoting labor productivity (real GPP per man-hour) in prefecture r in year t by y_r, we can represent the coefficient of unconditional β-convergence of labor productivity, β_y, as follows:

$$\beta_y = \frac{\sum_r (Gy_r - \overline{Gy})(y_r - \bar{y})}{\sum_r (y_r - \bar{y})(y_r - \bar{y})}.$$

Variables with an upper bar denote the simple average for all prefectures. Given the definition of $GTFP_r$, the equality $Gy_r = GTFP_r + Gz_r + Gq_r$ always holds, so that we obtain the following equation:

$$\beta_y = \beta_{TFP} + \beta_z + \beta_q,$$

where the β's on the right-hand side represent the estimated coefficients of simple linear regressions of each of the items on the right-hand side of equation (5.5) on labor productivity at the starting period. For example:

$$\beta_{TFP} = \frac{\sum_r (GTFP_r - \overline{GTFP})(y_r - \bar{y})}{\sum_r (y_r - \bar{y})(y_r - \bar{y})}.$$

In other words, the coefficient of unconditional β-convergence for labor productivity is equivalent to the sum of the regression coefficients obtained when conducting simple regressions of each of the sources of growth (shown in the growth accounting exercise above) on labor productivity in the initial period. The results of this factor decomposition of β-convergence based on the above approach are shown in Table 5.3. It should be noted that because the periods examined in Table 5.3 differ in length, we transformed all values that change over time into annual rates of change in order to make it possible to compare the results for the different periods.

The results in the table allow the following observations. We find

Table 5.3 Factor decomposition of β-convergence in labor productivity

	1955–1970	1970–1990	1990–2008	1955–2008
Coefficient of regressing labor productivity growth on labor productivity level in the starting year of the period	−0.028*** (0.004)	−0.015*** (0.004)	−0.015*** (0.005)	−0.014*** (0.001)
Contribution of TFP growth	−0.018*** (0.005)	−0.010** (0.004)	−0.009** (0.005)	−0.008*** (0.001)
Contribution of increases in the capital–labor ratio	−0.007*** (0.003)	−0.009*** (0.003)	−0.009*** (0.002)	−0.007*** (0.001)
Contribution of labor quality improvements	−0.002 (0.002)	0.003*** (0.001)	0.003** (0.002)	0.002* (0.001)

Notes:
1. Standard errors in parentheses. ***, **, and *denote statistical significance at the 1%, 5%, and 10% levels, respectively.
2. TFP growth includes capital quality improvements. Moreover, results for periods including the year 1970 exclude Okinawa.

evidence of β-convergence for all periods. However, the speed of β-convergence slowed from 1970 onward. Looking at the contribution of each factor to convergence, the table shows that TFP and the capital–labor ratio contributed to convergence in all periods. Of the two, the contribution of TFP growth to convergence was noticeably greater than that of the increase in the capital–labor ratio in the 1955–1970 period, but in subsequent periods as well as for the period as a whole, the contribution of the two factors is more or less the same. On the other hand, labor quality did not contribute to convergence in any of the periods and in fact from 1970 onward actually clearly worked in the direction of divergence. The results are consistent with those presented in Figure 5.3.

Looking at the results in Table 5.3 here and those in Table 5.1 earlier, the two may at first glance appear to be inconsistent. To recall, Table 5.1 indicated that until 1990 the reduction in differences in labor quality contributed to the reduction in labor productivity differences. In contrast, the results in Table 5.3 suggest that, depending on the period in question, labor quality improvements either did not contribute to convergence or actually worked against it. However, it is important to note that the approaches underlying the results in the two tables differ. Those in Table 5.1 are based on a cross-section analysis focusing on σ-convergence in the distribution of productivity differ-

ences, where the dispersion of the log of prefectural relative labor productivity (the square root of which approximately corresponds to the coefficient of variation of prefectural differences in labor productivity) is decomposed into the sum of the covariances between the log of prefectural relative labor productivity and the supply-side determinants of prefectural labor productivity differences. In contrast, the results in Table 5.3 are based on a decomposition of β-convergence in a time-series dimension. As is well known, results often differ depending on whether one focuses on σ-convergence or β-convergence due to factors such as idiosyncratic shocks across regions and terms of trade effects.

5.4 Economic convergence and the role of migration, capital accumulation, and TFP

The analysis in Sections 5.2 and 5.3 showed that, along with the reduction in prefectural differences in TFP, the reduction in prefectural differences in the capital-labor ratio made a large contribution to economic convergence. In particular, we found that from 1970 onward prefectures with high labor productivity tended to experience a slower increase in the capital-labor ratio and vice versa. This kind of pattern could be the result either of labor moving from low-productivity to high-productivity prefectures or of more rapid capital accumulation in low-productivity than in high-productivity prefectures. In this section, we examine which of these two mechanisms is responsible for the reduction in prefectural differences in the capital-labor ratio and prefectural economic inequality more generally in Japan.

As mentioned in the introduction to this chapter, the analysis in this section is complementary to that in Chapter 4. Therefore, to make the analysis here directly comparable to that in Chapter 4, we focus on the impact of migration, capital accumulation, and TFP growth not on labor productivity—as we did in the preceding sections—but on per capita GPP.

In order to examine the extent to which labor migration as well as prefectural differences in capital accumulation, improvements in labor quality, and TFP growth each contributed to economic convergence, we conduct the decomposition outlined below. In doing so, we treat Greater Tokyo (Tokyo, Kanagawa, Chiba, and Saitama) and Greater

Osaka (Osaka, Kyoto, Hyogo, Nara, and Shiga) as one area each to remove the distorting impact of commuting.[4]

We start by transforming equation (5.4), which defines TFP growth in prefecture r from year t to $t+\tau$, to obtain the following equation:

$$\begin{aligned}\Delta\ln A_{r,t} &= \Delta\ln Y_{r,t} - \Delta\ln N_{r,t} - \frac{1}{2}(\theta^K_{r,t}+\theta^K_{r,t+\tau})\,\Delta\ln Z_{r,t} \\ &- \frac{1}{2}(\theta^L_{r,t}+\theta^L_{r,t+\tau})(\Delta\ln H_{r,t}-\Delta\ln N_{r,t}) - \frac{1}{2}(\theta^L_{r,t}+\theta^L_{r,t+\tau})\,\Delta\ln q_{r,t} \\ &+ \frac{1}{2}(\theta^K_{r,t}+\theta^K_{r,t+\tau})\,\Delta\ln N_{r,t},\end{aligned} \tag{5.6}$$

where $N_{r,t}$ stands for the population of prefecture r in year t. As explained in Chapter 4, using this relationship, we obtain the following equation decomposing growth in per capita GPP:

$$\begin{aligned}\Delta\ln Y_{r,t} - \Delta\ln N_{r,t} &= \Delta\ln A_{r,t} + \frac{1}{2}(\theta^K_{r,t}+\theta^K_{r,t+\tau})\,\Delta\ln Z_{r,t} \\ &+ \frac{1}{2}(\theta^L_{r,t}+\theta^L_{r,t+\tau})(\Delta\ln H_{r,t}-\Delta\ln N_{r,t}) + \frac{1}{2}(\theta^L_{r,t}+\theta^L_{r,t+\tau})\,\Delta\ln q_{r,t} \\ &- \frac{1}{2}(\theta^K_{r,t}+\theta^K_{r,t+\tau})\,\Delta\ln N_{r,t}.\end{aligned} \tag{5.7}$$

The equation implies that increases in prefectures' per capita GPP can be decomposed into the contributions of TFP growth, capital accumulation, increases in per capita working hours, improvements in labor quality, and decreases in the population.

In order to examine the role that each of these factors played in

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[4] As mentioned in Chapter 4, the population and output shares of prefectures in the Greater Tokyo and Greater Osaka areas differ considerably in the post-war period as a result of commuting. This means that the output produced by commuters from, e.g., Saitama, is counted toward the output of Tokyo, thus distorting the per capita GPP of the two prefectures. Because the analysis in Chapter 4 covers both the pre-war period, when there was little commuting, and the post-war period, we did not treat the major urban agglomerations as one area each. However, because in this chapter we focus on the post-war period only, we remove this distortion.

the reduction in differences in per capita GPP, let us decompose the β-convergence coefficient for per capita GPP—that is, the coefficient when regressing the growth in per capita GPP on the left-hand side of equation (5.7) on per capita GPP in the starting year of the period—on the factors on the right-hand side of equation (5.7). To do so, as explained in Section 5.3, we can conduct a simple regression of each term on the right-hand side on per capita GPP in the starting year of the period and compare the regression coefficients. As in Section 5.3, for the regression we transform all values representing changes over time into annual rates.

The results of the decomposition are presented in Table 5.4 and show the following. First, as in the case of labor productivity, we find evidence of β-convergence in per capita GPP in all periods. Second, TFP growth consistently in all periods worked in the direction of reducing regional income inequality. The contribution of TFP growth to economic convergence was particularly large in the 1955–1970 period. Third, the population growth rate also consistently in all periods worked in the direction of reducing regional income inequality, and again the effect was particularly large in 1955–1970. As seen in Chapter 4, regional migration in Japan was particular pronounced during this period as the post-war baby boomer generation grew up, accelerating convergence. Fourth, although capital accumulation worked in the direction of divergence in 1955–1970, after that it worked in the direction of convergence. Exactly the same pattern can be observed for per capita working hours. Fifth, turning to labor quality, no clear effects can be observed during 1955–1970, but subsequently it worked in the direction of divergence. As explained in Chapter 4, the reason that labor quality worked in the direction of divergence likely is not that there was a brain drain, with better-educated individuals migrating from richer to poorer areas, but that those born in richer areas received more education.

Looking at the period 1955–2008 overall, the main factor contributing to the reduction in economic inequality was TFP growth, and although capital accumulation as well as migration also played a role, their contribution to the reduction in regional economic inequality was only about a third as large as that of TFP growth. On the other hand, improvements in labor quality worked in the direction of increasing inequality.

Table 5.4 Factor decomposition of β-convergence in GPP per capita

	1955–1970	1970–1990	1990–2008	1955–2008
Coefficient of regressing per capita GPP growth on per capita GPP in the starting year of the period	−0.018***	−0.022***	−0.020***	−0.012***
	(0.005)	(0.004)	(0.005)	(0.002)
Contribution of TFP growth	−0.022***	−0.010**	−0.009**	−0.009***
	(0.005)	(0.004)	(0.005)	(0.001)
Contribution of capital accumulation	0.004	−0.006*	−0.006**	−0.003*
	(0.004)	(0.003)	(0.002)	(0.002)
Contribution of growth in per capita working hours	0.008***	−0.004**	−0.004**	0.001
	(0.002)	(0.002)	(0.002)	(0.001)
Contribution of improvements in labor quality	0.000	0.003***	0.003**	0.003***
	(0.002)	(0.001)	(0.002)	(0.001)
Contribution of decline in population growth rate	−0.008***	−0.006***	−0.005***	−0.003*
	(0.003)	(0.002)	(0.001)	(0.001)

Notes:
1. Standard errors in parentheses. ***, **, and *denote statistical significance at the 1%, 5%, and 10% levels, respectively.
2. TFP growth includes capital quality improvements. Moreover, results for periods including the year 1970 exclude Okinawa.

Having examined the relative importance of the different factors of production as well as TFP in economic convergence, let us now look at some of these items in greater detail. The role of migration and improvements in labor quality were already discussed in Chapter 4. The focus of the remainder of this section therefore is on capital accumulation and changes in TFP.

The increase in capital stock in prefecture r from year t to year $t+1$ can be represented as follows:

$$\frac{\Delta Z_{r,t}}{Z_{r,t}}=\frac{I_{r,t}}{Z_{r,t}}-\delta=\left(\frac{S_{r,t}}{Y_{r,t}}+\frac{I_{r,t}-S_{r,t}}{Y_{r,t}}\right)\frac{Y_{r,t}}{Z_{r,t}}-\delta, \tag{5.8}$$

where $I_{r,t}$ stands for gross investment, δ for the depreciation rate of capital, $Y_{r,t}$ for gross value added (GPP), and $S_{r,t}$ for gross savings. On the right-hand side of equation (5.8), $S_{r,t}/Y_{r,t}$ represents the share of gross savings in GPP, $(I_{r,t}-S_{r,t})/Y_{r,t}$ is the part of gross prefectural investment that is covered by external savings (savings "imported" from outside the prefecture) relative to GPP, and $Y_{r,t}/Z_{r,t}$ is the average productivity of capital (the inverse of the capital coefficient). Meanwhile, $(I_{r,t}-S_{r,t})/Y_{r,t}$, in addition to capital inflows to prefecture r,

includes receipts of capital transfers from other prefectures. Below, we will refer to $(I_{r,t}-S_{r,t})/Y_{r,t}$ as the net capital inflow–GPP ratio.

It should be noted that due to the way that investment in social capital is treated in the R-JIP Database, the first equality in equation (5.8) only holds as an approximation. Specifically, what may be called broad social capital accumulation consists of both the construction of public schools, national hospitals, government office buildings, etc., which in the R-JIP Database is included in the capital stock (Z) in government services, and investment in public roads and port facilities, expenditures for national land conservation, etc. Because the latter, which we will refer to as narrow social capital accumulation, is not classified into specific industries in the fixed capital formation matrix of the Input-Output Tables by the Ministry of Internal Affairs and Communications, on which the R-JIP Database is based, it is not included in changes in Z. This means that whereas narrow social capital is included in the data for gross investment $I_{r,t}$ in equation (5.8), it is not included in the data for $\Delta Z_{r,t}$.

In previous studies on economic convergence, such as Barro and Sala-i-Martin (1991, 1992b), Sala-i-Martin (1996), and Shioji (2001), it is assumed that the key driver of regional convergence is diminishing marginal returns to capital. That is, it is assumed that capital accumulation in richer, more capital-intensive regions decelerates as marginal returns to capital decline, lowering the rate of per capita output growth. Thus, these studies suggest that, as in a Solow-type closed-economy neoclassical growth model (Solow, 1956), interregional capital and labor movements essentially play no role in regional convergence.

The assumption made in these studies can be directly examined using equation (5.8). Specifically, they assume that the gross saving rate $S_{r,t}/Y_{r,t}$ is identical across prefectures and that gross capital inflows or the ratio of capital transfer receipts $(I_{r,t}-S_{r,t})/Y_{r,t}$ are zero. On the other hand, they assume that the average productivity of capital $Y_{r,t}/Z_{r,t}$ of richer prefectures decreases due to diminishing marginal returns to capital and that, as a result, the growth rate of capital stock $\Delta Z_{r,t}/Z_{r,t}$ on the left-hand side also decreases for richer prefectures. Using our database, we can directly examine whether this hypothesis is correct for the convergence in per capita GPP differences in post-war Japan.

Table 5.5 Prefectural capital accumulation

	1955–1970	1970–1990	1990–2008	1955–2008
Growth of capital stock	0.014*	−0.024***	−0.013**	−0.006
($\Delta Z/Z$)	(0.008)	(0.008)	(0.005)	(0.004)
Gross invesment-GPP ratio	−0.079***	−0.145***	−0.111***	−0.091***
(I/Y)	(0.025)	(0.026)	(0.017)	(0.018)
Gross savings-GPP ratio	0.149**	0.198***	0.218***	0.118**
(S/Y)	(0.055)	(0.069)	(0.067)	(0.055)
Gross capital inflows-GPP ratio	−0.228***	−0.343***	−0.329***	−0.209***
($(I-S)/Y$)	(0.059)	(0.073)	(0.073)	(0.062)
Average productivity of capital	−0.024	−0.059	0.125***	0.020
(Y/K)	(0.118)	(0.054)	(0.038)	(0.054)

Notes:
1. The table shows the coefficient estimates when regressing the variable on per capita GPP at the start of the period.
2. Standard errors in parentheses. ***, **, and *denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5.5, for the periods 1955–1970, 1970–1990, 1990–2008, and for the entire period from 1955 to 2008 covered by our database, shows the coefficient estimates when regressing the period average of the growth rate of prefectural capital stock $\Delta Z_{r,t}/Z_{r,t}$, the gross investment rate $I_{r,t}/Y_{r,t}$, the gross saving rate $S_{r,t}/Y_{r,t}$, the ratio of gross capital inflows or capital transfer receipts $(I_{r,t}-S_{r,t})/Y_{r,t}$, and the average productivity of capital $Y_{r,t}/Z_{r,t}$ on per capita GPP at the start of the period.

Starting with the regression result for the growth rate of the capital stock, $\Delta Z_{r,t}/Z_{r,t}$, on the left-hand side of equation (5.8), we find that richer prefectures had a higher growth rate than poorer prefectures in 1955–1970, which tended to contribute to an increase in inequality. However, in each of the subsequent periods, poorer prefectures had a higher growth rate, contributing to a decrease in inequality. This is consistent with the result in Table 5.4 indicating that capital accumulation contributed to convergence in labor productivity.

Next, looking at the regression for the period average gross investment-GPP ratio $(I_{r,t}/Y_{r,t})$ on per capita GPP at the beginning of the period, we find that the gross investment-GPP ratio is larger in poorer prefectures not only in the latter two periods, but also in 1955–1970, although the absolute value of the regression coefficient is smaller than in that later periods.

The result that the regression coefficients for the growth rate of

the capital stock and for the gross investment–GPP ratio in the 1955–1970 period have opposite signs (the former is positive, while the latter is negative) is due to the fact that, as explained above, our capital stock data do not include narrow social capital, whereas the gross investment data do. The result thus implies that although richer prefectures accumulated capital other than narrow capital (i.e., capital stock covered in the R-JIP Database) faster than poorer prefectures, investment overall (i.e., including narrow social capital) grew faster in the poorer prefectures, i.e., they had a higher gross-investment GPP ratio, because of the faster accumulation of narrow social capital (with the latter tendency continuing after 1970).

Next, looking at the sources of investment, the gross savings–GPP ratio, $S_{r,t}/Y_{r,t}$, tended to be higher in richer prefectures in all periods. On the other hand, net capital inflows or capital transfer receipts, $(I_{r,t}-S_{r,t})/Y_{r,t}$, were higher in poorer prefectures in all periods, consistently contributing to the reduction in inequality. Comparing the regression coefficients for net capital inflows/capital transfer receipts and the gross savings–GPP ratio, we find that the former is greater than the latter in all periods, implying that although the gross saving rate was higher in richer prefectures, capital movements and capital transfers exceeding differences in gross saving rates took place, and this likely contributed to the decline in prefectural GPP differences. This finding is in line with the argument by Dekle (1996) that there were substantial capital movements across Japanese prefectures and that although richer prefectures had higher saving rates, these were not linked to higher prefectural investment rates.[5] Reasons for the movement of capital as well as capital transfers from richer to poorer prefectures are the increasing relocation of factories by firms to rural regions especially from the 1970s onward (see, e.g., Yue, 2000) as well as capital transfers by the government from richer to poorer prefectures, which, as pointed out by Fukao and Yue (2000), played an important role.

Finally, looking at prefectural differences in the average productivity of capital, we find that the average productivity of capital

[5] Specifically, Dekle (1996) points out that the cross-section correlation between prefectural private savings rates and private investment rates is close to zero and capital movements between prefectures were extremely active.

tended to be lower in richer prefectures. As seen in Figure 5.1 in 1955, there were large prefectural differences in the capital-labor ratio, and the average productivity of capital in prefectures with particularly high capital-labor ratios likely was comparatively low due to diminishing marginal returns to capital. Nevertheless, we find that although the estimated coefficient when regressing the period average of the average productivity of capital (Y/Z) on the per capita GPP level at the beginning of the period is negative until 1990, it is not statistically significantly different from zero. Moreover, from 1990 onward, probably reflecting the decline in prefectural differences in capital-labor ratios and the existence of TFP differences as seen in Figure 5.2, the average productivity of capital was in fact significantly higher in richer prefectures. These results suggest that the convergence mechanism assumed in Solow-type growth models, in which regional inequality declines because richer prefectures have a higher capital-labor ratio and lower marginal returns to capital, did not play a central role in the decline in prefectural inequality in post-war Japan.

The above results on the role of capital accumulation in the reduction of prefectural inequality in per capita GPP can be summarized as follows. Before 1970, capital accumulation—measured in terms of the capital stock covered in the R-JIP Database, i.e., excluding narrow social capital—proceeded at a faster pace in richer than in poorer prefectures. However, from 1970, the rate of capital accumulation was consistently higher in the poorer prefectures. Moreover, overall gross investment—as measured by the gross investment-GPP ratio and including narrow social capital—has been consistently higher in poorer prefectures since the start of our observation period in 1955. Turning to the sources of funding for investment, we found that although the gross savings-GPP rate was consistently higher in richer prefectures, there were even greater capital movements and transfers from richer to poorer prefectures. Thus, from 1970 onward, the main reason that capital accumulation contributed to a decline in prefectural inequality was these capital movements and transfers, while the convergence mechanism through diminishing marginal returns to capital assumed in Solow-type growth models played almost no role.

Next, let us consider the role played by TFP growth in the decline in prefectural inequality. Above, we examined the sources of the decline in prefectural inequality using various supply-side

approaches, such as level accounting for 1955 and 2008 regarding prefectural differences in labor productivity (Figures 5.1 and 5.2), factor decomposition of (the log of) prefectural labor productivity differences (Table 5.1), growth accounting of labor productivity growth (Figure 5.3), and the decomposition of β-convergence in labor productivity and per capita GPP (Tables 5.3 and 5.4). These different analyses all showed that the major cause of the decline in prefectural labor productivity differences and per capita GPP differences between 1955 and 2008 was the decline in prefectural TFP differences. Let us therefore examine what caused this decline in TFP differences.

Put simply, the major driving force leading to the decline in TFP differences probably was the expansion of high-productivity firms from metropolitan prefectures into more rural prefectures. In response to increasingly stringent regulations on industrial sites to deal with pollution as well as growing labor shortages in metropolitan areas from the late 1960s onward, firms in many manufacturing industries increasingly tended to set up new factories in low-wage rural areas.[6] Given that the technological knowledge accumulated by firms has strong public good characteristics within the same firm, this means that rural areas likely received considerable knowledge transfers. Moreover, the expansion of manufacturing industry into rural areas likely also had the effect of raising labor productivity in these areas through industrial agglomeration effects.

Another potentially important factor likely was the improvement of social infrastructure in rural areas, which the government regarded as vital. To examine this issue, Figure 5.4 shows the relationship between the narrow social capital stock divided by working hours and per capita GPP for each prefecture in 1955, 1970, 1990, and 2008.[7] Specifically, the figure was constructed by first taking the log of both variables and then calculating the difference from the national average. As mentioned above, narrow social capital, which includes expenditure on public roads, port facilities, and national land conservation, is

[6] See, for example, Fukao and Yue (1997), who examined the locational choices of firms in the electrical machinery industry and showed that firms were looking for low-cost labor and expanded into rural areas.

[7] We measure social capital accumulation relative to working hours (rather than per capita) in order to take into account differences in demographic structure.

not included in the capital stock in the R-JIP Database.[8]

As can be seen in Figure 5.4, the relationship between prefectures' per capita GPP and social capital per working hour changed substantially over time. In 1955, richer prefectures tended to have higher social capital per working hour. However, by 1970, this positive correlation had disappeared, and from 1990 onward there is in fact a strong negative relationship between the two variables. While the correlation coefficient of the two variables is 0.130 for 1955 and −0.179 for 1970, we subsequently observe an extremely large negative correlation, with correlation coefficients of −0.590 for 1990 and −0.482 for 2008 (the null hypothesis of no correlation is rejected at the 1% significance level for both 1990 and 2008). In other words, the poorer a prefecture is, the more narrow social capital investment it has had. Poorer prefectures received large capital transfers from the central government, which contributed to building up narrow social capital.

Given that the accumulation of social capital likely increases the efficiency of economic activity and hence has a positive effect on TFP, the fact that social capital accumulation from 1955 onward has consistently concentrated particularly on poorer rural areas very likely contributed to the decline in prefectural TFP differences. At the same time, however, it should also be noted that the rapid accumulation of social capital in poorer regions probably resulted in a misallocation of social capital across regions from the viewpoint of efficiency within the country as a whole. Yoshino and Nakajima (1999), for example, estimating regional[9] production functions for each sector using data for 1975–1994, highlight that the marginal productivity of social capital tended to be much lower in poorer than in richer regions.

5.5 Conclusion

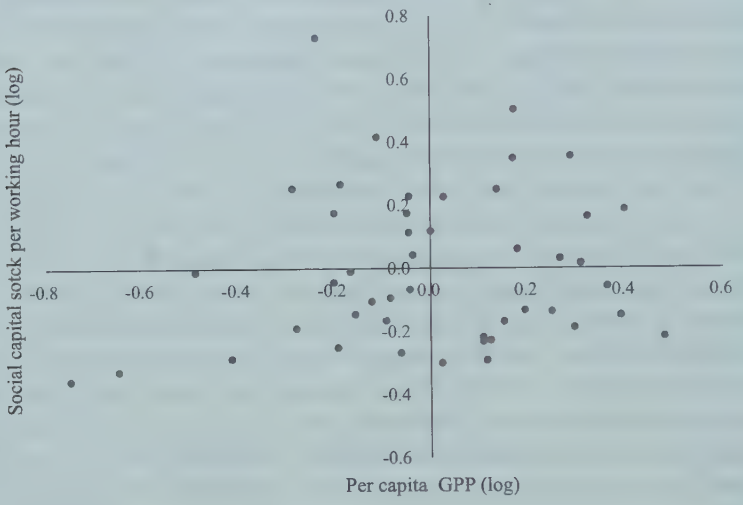
In this chapter, using the R-JIP Database, which provides data on aggregate industry value added and production factor inputs by prefecture for 1955–2008, we examined the reasons for the decline in prefectural economic inequality from the supply side. To this end, we

[8] We obtained the prefecture-level narrow social capital stock data from Director General for Economic, Fiscal and Social Structure (2012).

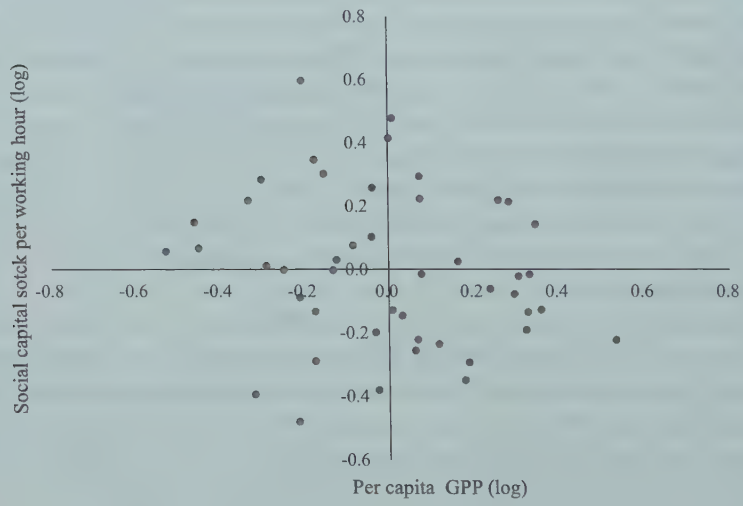
[9] They aggregated Japan's 47 prefectures into 11 regions.

Figure 5.4 Relationship between per capita GPP and prefectural social capital stock per working hour

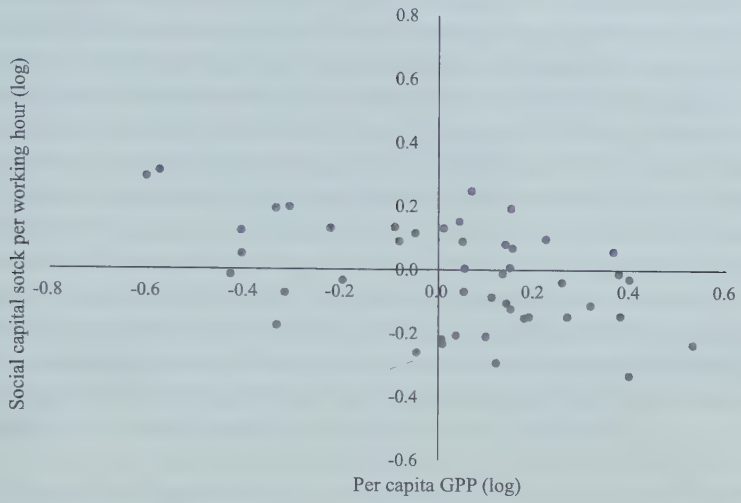
(a) 1955



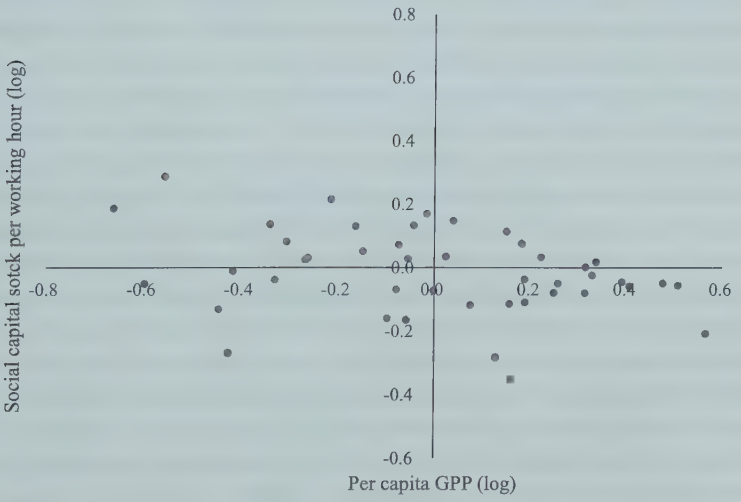
(b) 1970



(c) 1990



(d) 2008



Note: The figure shows the difference from the national average after taking the log of per capita GPP and prefectural social stock per working hour.

employed a variety of approaches, such as level accounting for 1955 and 2008 regarding prefectural differences in labor productivity (Figures 5.1 and 5.2), factor decomposition of (the log of) prefectural labor productivity differences (Table 5.1), growth accounting of labor productivity growth (Figure 5.3), and the decomposition of β-convergence in labor productivity and per capita GPP (Tables 5.3 and 5.4). We also compared our results with level accounting analyses on the United States (Turner et al., 2010) and OECD countries (Caselli, 2005) (Table 5.2).

In addition, we focused on the role of capital accumulation and changes in TFP in economic convergence. We examined how the relatively rapid capital accumulation in low-income prefectures was financed and what brought the decline in differences in TFP about.

The main findings of the analysis are as follows.

1. Taking a supply-side approach, we examined three possible factors underlying labor productivity differences across prefectures: differences in capital-labor ratios, differences in labor quality, and differences in TFP. We found that, in the period from 1955 to 2008 all three factors consistently contributed to prefectural differences in labor productivity. In 1955, the most important reason for prefectural labor productivity differences was differences in TFP, followed by differences in capital-labor ratios, and then by differences in labor quality. Differences in capital-labor ratios and TFP declined substantially between 1955 and 2008, leading to a dramatic reduction in prefectural labor productivity differences. On the other hand, depending on the period, prefectural differences in labor quality either did not contribute to the contraction in labor productivity differences or in fact worked in the direction of increasing such differences. As a result of these changes, while TFP differences continued to be the major reason for prefectural labor productivity differences in 2008, the contribution of differences in the capital-labor ratio fell to the same level as the contribution of labor quality differences (Table 5.1).

2. Taking a closer look at the results for each period, we found that during the high-speed growth era from 1955 to 1970 the main fac-

tor underlying the decline in prefectural labor productivity differences was the decline in TFP differences. On the other hand, from 1970 onward, Japan experienced a strong decline in regional differences in inputs, so that the contribution of variation in inputs to variation in output steadily dropped after 1970. As a result, the regional variance of inputs in Japan was less than half of the US value and only about 6% of the variance across OECD countries (Tables 5.1 and 5.2). This drop in regional differences in inputs since 1970 was the consequence of a decline in regional differences in the capital–labor ratio (Tables 5.1 and 5.3). In contrast, differences in labor quality only marginally contributed to the decline in labor productivity differences during the high-speed growth era and more recently in fact seem to have worked in the direction of increasing labor productivity differences (Table 5.3).

3. Further, in order to supplement the analysis in Chapter 4 examining the role of migration in the decline in per capita GPP differences, we examined the role of factors other than migration in economic convergence. Specifically, we did so by decomposing β-convergence in per capita GPP into the contribution of TFP differences, capital accumulation, changes in per capita working hours, changes in labor quality, and migration (Table 5.4). The results indicate that migration from poorer to richer prefectures and the decline in prefectural TFP differences from 1955 to 2008 consistently contributed to the decline in per capita GPP differences, although—for the period as a whole—the contribution of the decline in prefectural TFP differences to β-convergence was more than twice as large as the contribution of migration. On the other hand, capital accumulation actually worked in the direction of increasing prefectural inequality in the period 1955–1970, but from 1970 onward consistently operated in the direction of reducing inequality. Meanwhile, changes in labor quality from 1970 onward stymied the decline in inequality. However, the analysis in Chapter 4 suggested that the fact that changes in labor quality worked against convergence likely was not the result of a brain drain in which better educated workers migrated to richer areas, but was caused by the fact that children raised in richer areas received more education.

4. We further examined in this chapter why, from 1970 onward, poorer prefectures tended to have higher capital stock growth rates than richer prefectures. Three possible explanations of this pattern offer themselves: (1) the poorer a prefectures, the higher the gross savings-GPP ratio; (2) poorer prefectures received private capital inflows and/or government capital transfers; and/or (3) the richer a prefecture, the higher the capital-labor ratio, so that the capital coefficient (capital stock-GPP ratio) declines over time through diminishing returns to capital, lowering the growth rate of the capital stock (i.e., the convergence mechanism through diminishing marginal returns to capital assumed in Solow-type growth models). Our results show that the gross savings-GPP ratio has tended to be lower in poorer prefectures in all periods from 1955 to 2008, thus ruling out the first possible explanation. Instead, poorer prefectures tended to receive higher capital inflows and/or government capital transfers relative to GPP, and it is this—i.e., the second explanation—that raised the growth rate of the capital stock in poorer prefectures. On the other hand, the convergence mechanism assumed in Solow-type growth models, i.e., the third explanation based on diminishing returns to capital, played almost no role in explaining higher capital stock growth rates in poorer prefectures.

5. Finally, we found that the accumulation of social capital, measured in relation to working hours, in post-war Japan was concentrated in prefectures with lower per capita GPP. In particular from 1990 onward, there was a clear pattern that the lower per capita GPP, the higher was the social capital stock per working hour. Given that the accumulation of social capital likely raises the efficiency of economic activity and hence has a positive effect on TFP, the emphasis on improving social infrastructure in poorer rural areas very likely contributed to the decline in prefectural TFP differences. Meanwhile, the expansion of firms with high labor productivity into rural areas and technology transfers to technologically lagging prefectures through intra-firm technology diffusion, as well as the growing agglomeration of industry in rural areas through the expansion of manufacturing in rural areas (discussed in greater

detail in the next chapter) also likely greatly contributed to the decrease in prefectural TFP differences.

Preceding studies by Barro and Sala-i-Martin (1991, 1992b) as well as Shioji (2001) treated convergence as a "black box." Using a growth accounting framework and the R-JIP Database, we decomposed growth in labor productivity and per capita GPP into supply-side factors such as TFP, capital accumulation, and labor migration. We examined how capital accumulation in each prefecture was financed either through "domestic" saving or capital inflows and capital transfers. In this manner, we opened the "black box" and were able to show that the mechanism assumed in preceding studies played only a negligible role. Opening this black box has shown that convergence cannot be reduced to one simple mechanism, but is a complex process driven by a number of factors that may work in different directions and that may be of varying importance at different points in time.

Chapter 6

Industry-Level Factor Inputs and TFP, and Regional Convergence: 1970-2008

6.1 Introduction

Focusing on the period from 1955 to 2008, the preceding chapter examined developments in prefectural factor inputs and their role in the convergence of prefectural labor productivity. It was shown that prefectural differences in the capital-labor ratio, labor quality, and total factor productivity (TFP) to different degrees all contributed to regional inequality in labor productivity at the start of the period in 1955. However, over time, prefectural differences in all three determinants of regional inequality in labor productivity declined, so that by 2008, the productivity gap between leading and lagging prefectures had shrunk considerably.

A shortcoming of the analysis in the preceding chapter, however, was that the data available for that period were aggregated at the prefectural level, that is, for all industries together. Yet, capital-labor ratios and human-capital intensity differ considerably across industries. This means that the mechanism underlying the convergence in capital-labor ratios, etc., which in turn drove the convergence in labor productivity, remained unclear. One possibility, for example, is that physical and human capital-intensive industries with high labor productivity may have been concentrated in certain prefectures at the start of the period, but became more evenly dispersed across Japan

over time, thus resulting in labor productivity convergence. Another possibility, however, is that there were substantial differences in physical and human capital-intensity within the *same* industry at the start of the period, but these within-industry differences declined over time. Of course, it is also possible that the labor productivity convergence was driven by a combination of the two mechanisms.

Thus, in order to gain a better understanding of the mechanisms driving labor productivity convergence, it is necessary to examine the determinants of labor productivity at the industry level for each prefecture. The data necessary for such an analysis have recently become available in the form of the Regional-Level Japan Industrial Productivity (R-JIP) Database jointly compiled by the Research Institute of Economy, Trade and Industry (RIETI) and Hitotsubashi University. Covering the period from 1970 to 2008, the R-JIP Database comprises annual output and factor input data for Japan's 47 prefectures classified into 23 industries.[1] Using the R-JIP data, the present chapter attempts to obtain a more detailed picture of the forces driving productivity convergence in Japan by examining the role of changes in prefectural industry structures and industry-level factor intensities.[2]

The remainder of the chapter is organized as follows. Section 6.2 presents a decomposition of prefectural differences in labor productivity into the contribution of differences in prefectural industrial structures and the contribution of within-industry differences in labor productivity in order to examine the mechanism underlying the observed convergence in prefectural labor productivity. Moreover, within-industry differences in labor productivity are further decomposed into the contribution of capital-labor ratios, labor quality, and TFP in order to examine their respective contributions to labor productivity differences within the same industry across prefectures. Next, Section 6.3

[1] Specifically, the R-JIP Database contains data on nominal and real value added, capital stock, labor input, social capital stock, estimates of the TFP level and TFP growth, etc., broken down into 23 industries for each of the 47 prefectures. (Data for Okinawa prefecture are available from 1972.) Further details on the R-JIP Database can be found in Appendix 4.

[2] The present chapter is an extension of research reported in Tokui, Makino, Fukao et al. (2013) and forms part of our research at the Research Institute of Economy, Trade and Industry (RIETI).

focuses on prefectural differences in capital-labor ratios, labor quality, and TFP and decomposes these into the share effect due to differences in industry structures and the within-industry effect due to prefectural differences in factor intensities within the same industry. Based on the decomposition in Section 6.3, Section 6.4 then focuses on the correlation between the share and within-industry effects on the one hand and prefectural differences in labor productivity on the other in order to investigate for the different industries how the share and within-industry effects are related to differences in labor productivity.

6.2 Decomposition of labor productivity differences

The analysis in Chapter 3 (Table 3.3) looking at labor productivity in very broadly defined industry categories indicated that the concentration of industries with high labor productivity in prefectures with high per capita income was a key factor underlying differences in prefectural per capita incomes overall. Moreover, the contribution of such differences in industrial structure to prefectural income inequality overall followed an inverted U curve, generally increasing during the pre-war period and decreasing during the post-war period. On the other hand, labor productivity differences within these broad industry categories declined over time and thus worked in the direction of reducing prefectural income inequality. However, because the data used for the analysis in Chapter 3 do not include information on capital input and, for labor input, only include the number of employed persons, but not information on working hours and labor quality, the contributions of prefectural differences in capital input, working hours, labor quality, and TFP are all included in the contribution of differences in labor productivity within the same industry. In other words, such differences in labor productivity within the same industry remained a black box.

In order to open this black box, we use the information on factor inputs and TFP provided in the R-JIP Database and focus on three benchmark years, 1970, 1990, and 2008. We begin our analysis by decomposing differences in labor productivity between the top and bottom 20% of prefectures in terms of labor productivity (where the top and bottom 20% are counted in terms of their cumulative population) into differences in industrial structure and differences in within-

within-industry differences in industry productivity. Moreover, we decompose the latter—that is, within-industry differences in productivity—into the contribution of differences in capital-labor ratios, differences in labor quality, and differences in TFP, and examine how these factors contributed to developments in prefectural labor productivity differences.[3] As a start, instead of looking at the 23 industry categories in the R-JIP Database, we aggregate the data for these industries into the four broad industry categories used in Chapters 2 to 4 (i.e., agriculture, forestry and fisheries; mining, manufacturing, and construction; domestic trade and services; and transport and communication) to make it possible to compare the results with those for the pre-war period.

Let us describe how we decompose prefectural differences in labor productivity. By definition, prefectural labor productivity consists of the product of the labor productivity in a particular industry in that prefecture and the labor input share (measured in man-hours) in that industry in that prefecture, aggregated over all industries. To start with, equation (6.1) below shows the decomposition of prefectural differences in labor productivity between the top 20% of prefectures and the national average, where subscript J denotes the national average, T denotes the top 20% of prefectures (in terms of their cumulative population) with the highest labor productivity for all industries, y denotes labor productivity for all industries, v^L_i denotes the labor input share of industry i, and y_i denotes labor productivity in industry i:

$$\ln\left(\frac{y_T}{y_J}\right) = \ln\left(\frac{\sum_{i=1}^{I} v^L_{i,T} y_{i,T}}{\sum_{i=1}^{I} v^L_{i,J} y_{i,J}}\right) = \ln\left(\frac{\sum_{i=1}^{I} v^L_{i,T} y_{i,T}}{\sum_{i=1}^{I} v^L_{i,J} y_{i,T}}\right) + \ln\left(\frac{\sum_{i=1}^{I} v^L_{i,J} y_{i,T}}{\sum_{i=1}^{I} v^L_{i,J} y_{i,J}}\right). \quad (6.1)$$

[3] It should be noted that labor productivity in this chapter is measured not in terms of the number of employed persons (i.e., value added/number of employed persons), but in terms of total man-hours (i.e., value added/man-hours).

In equation (6.1), the expression after the first equal sign shows the difference between the top 20% of prefectures and the national average for the labor productivity for all industries decomposed into labor productivity by industry and labor input share by industry. This is further decomposed into the two terms in the expression after the second equal sign by first dividing by the aggregated industry-level labor productivity levels in the top 20% of prefectures weighted by the national average industry-level labor input shares and then multiplying again by the same term.

The first term to the right of the second equal sign shows prefectural differences in labor productivity for all industries due to prefectural differences in the labor input share for each industry based on the industry-level labor productivity levels in the top 20% of prefectures. Put differently, the term represents that part of prefectural labor productivity differences caused by relative differences in industrial structure across prefectures. On the other hand, the second term represents the labor productivity difference between the top 20% of prefectures and the national average due to prefectural labor productivity differences within the same industry assuming that the industrial structure measured in terms of labor input shares was the same as the national average.

Using the value-added share ($v^{Y}_{i,J}$), the last term in equation (6.1) can be rewritten as follows:

$$\ln\left(\frac{\sum_{i=1}^{I} v^{L}_{i,J} y_{i,T}}{\sum_{i=1}^{I} v^{L}_{i,J} y_{i,J}}\right) = \ln\left(\sum_{i-1}^{I} v^{Y}_{i,J}\left(\frac{y_{i,T}}{y_{i,J}}\right)\right). \tag{6.2}$$

Further, using linear approximation of equation (6.2) around $y_{i,T}/y_{i,J}=1$, the following relationship is obtained: [4]

$$\ln\left(\sum_{i=1}^{I} v^{Y}_{i,J}\left(\frac{y_{i,T}}{y_{i,J}}\right)\right) \approx \sum_{i=1}^{I} v^{Y}_{i,J} \ln\left(\frac{y_{i,T}}{y_{i,J}}\right). \tag{6.3}$$

Using equations (5.2) and (5.3) from Chapter 5, each $\ln(y_{i,T}/y_{i,J})$ in equation (6.3), which is the logarithm of the relative labor productivity in the top 20% of prefectures in a particular industry to the

national average labor productivity in that industry, can be decomposed into three components: the TFP level, the capital-labor ratio, and labor quality (all relative to the national average). Replacing the last term in equation (6.1) above with these three components, equation (6.1) can be rewritten as follows,[5] where the approximation error from equation (6.3) is explicitly taken into account and represented by the last term:

$$\begin{aligned}\ln\left(\frac{y_T}{y_J}\right) &= \ln\left(\frac{\sum_{i=1}^{I} v_{i,T}^{L} y_{i,T}}{\sum_{i=1}^{I} v_{i,J}^{L} y_{i,T}}\right) \\ &+ \sum_{i=1}^{I} v_{i,J}^{Y} RTFP_{i,T} + \sum_{i=1}^{I} v_{i,J}^{Y} \frac{1}{2}(\theta_{i,T}^{K} + \theta_{i,J}^{K}) \ln\left(\frac{z_{i,T}}{z_{i,J}}\right) \\ &+ \sum_{i=1}^{I} v_{i,J}^{Y} \frac{1}{2}(\theta_{i,T}^{L} + \theta_{i,J}^{L}) \ln\left(\frac{q_{i,T}}{q_{i,J}}\right) + \varepsilon'_{T,J}.\end{aligned} \tag{6.4}$$

Finally, because the same relationship as in equation (6.4) also holds for the prefectures with the lowest labor productivity (referred to as the bottom 20% of prefectures hereafter), the difference in labor productivity between the top and bottom 20% of prefectures can be expressed as follows:

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[4] To derive the right-hand side of (6.3), we apply the first-order Taylor approximation to the left hand side of the equation and then use the approximation $y_{i,T}/y_{i,J} - 1 \approx \ln(y_{i,T}/y_{i,J})$ assuming that each $y_{i,T}/y_{i,J}$ does not greatly differ from 1.

[5] In equation (6.4), θ^K stands for the capital cost share, θ^L for the labor cost share, $RTFP$ for relative TFP, z for the capital-labor ratio, and q for labor quality. The concept of relative TFP over cross-sectional data was first formally introduced by Caves, Christensen, and Diewert (1982). For details, also refer to Chapter 5.

$$
\begin{aligned}
&\ln\left(\frac{y_T}{y_B}\right) \\
&= \sum_{i=1}^{I} v_{i,J}^{Y}(RTFP_{i,T} - RTFP_{i,B}) \\
&+ \sum_{i=1}^{I} v_{i,J}^{Y}\left\{\frac{1}{2}(\theta_{i,T}^{K} + \theta_{i,J}^{K})\ln\left(\frac{z_{i,T}}{z_{i,J}}\right) - \frac{1}{2}(\theta_{i,B}^{K} + \theta_{i,J}^{K})\ln\left(\frac{z_{i,B}}{z_{i,J}}\right)\right\} \\
&+ \sum_{i=1}^{I} v_{i,J}^{Y}\left\{\frac{1}{2}(\theta_{i,T}^{L} + \theta_{i,J}^{L})\ln\left(\frac{q_{i,T}}{q_{i,J}}\right) - \frac{1}{2}(\theta_{i,B}^{L} + \theta_{i,J}^{L})\ln\left(\frac{q_{i,B}}{q_{i,J}}\right)\right\} \qquad (6.5) \\
&+ \ln\left(\frac{\sum_{i=1}^{I} v_{i,T}^{L} y_{i,T}}{\sum_{i=1}^{I} v_{i,J}^{L} y_{i,T}}\right) - \ln\left(\frac{\sum_{i=1}^{I} v_{i,B}^{L} y_{i,B}}{\sum_{i=1}^{I} v_{i,J}^{L} y_{i,B}}\right) \\
&+ \varepsilon'_{T,J} - \varepsilon'_{B,J}.
\end{aligned}
$$

where the first term on the right-hand side is the weighted TFP difference within each industry between the top and bottom 20% of prefectures, the second term is the weighted capital-labor ratio difference within each industry, the third term is the weighted labor quality difference within each industry, the fourth and fifth terms are prefectural differences in labor productivity due to differences in industrial structure, and the last two terms are approximation errors. The analysis in this section focuses on the first three terms representing prefectural differences within each industry.

The results of the factor decomposition of prefectural differences in labor productivity using equation (6.5) for the years 1970, 1990, and 2008 employing the R-JIP Database are shown in Table 6.1.

The table indicates that labor productivity differences between the top and bottom 20% of prefectures declined rapidly between 1970 and 1990 and continued to do so thereafter, albeit at a slower pace. This is in line with the results obtained in Chapters 3 and 5. However, since we are using industry-level data, we can now examine the reasons for the decline, which was not possible with the aggregate data used in Chapter 5.

Thus, looking at the factors underlying the observed decline in labor productivity differences, we find that this is more or less in line

Table 6.1 Factor decomposition of labor productivity differences between the top and bottom 20% of prefectures

	1970	1990	2008
Differences in labor productivity	0.642 (100.0)	0.454 (100.0)	0.435 (100.0)
Differences in industrial structure	0.275 (42.8)	0.119 (26.3)	0.102 (23.5)
Within-industry differences in labor productivity	0.367 (57.2)	0.335 (73.7)	0.333 (76.5)
Contribution of TFP	0.162 (25.3)	0.205 (45.2)	0.299 (68.7)
Contribution of capital-labor ratio	0.149 (23.2)	0.067 (14.7)	0.010 (2.3)
Contribution of labor quality	0.109 (16.9)	0.103 (22.7)	0.069 (15.9)
Measurement error	−0.053 (−8.2)	−0.040 (−8.8)	−0.045 (−10.4)

Note: All differences are expressed in logarithm. Figures in parentheses show the percentage contribution to overall labor productivity differences.

with the trend in differences in industrial structure, indicating that industrial structures in the top and bottom prefectures became increasingly similar over the roughly four decades we are examining here, and that this greatly contributed to the decline in labor productivity differences overall. In contrast, within-industry differences in labor productivity across prefectures declined only marginally over the same period and therefore hardly contributed at all to the reduction in prefectural labor productivity differences. In fact, within-industry differences in labor productivity explain more than half (57.2%) of the overall difference in labor productivity in 1970 and an even greater proportion thereafter (76.5% in 2008), meaning that within-industry labor productivity differences across prefectures are the main reason for regional differences in labor productivity overall.

The decomposition of within-industry labor productivity differences into differences in TFP, capital-labor ratios, and labor quality shows that although such within-industry differences show relatively little change over time, the factors contributing to them did shift considerably. Specifically, the contribution of TFP differences to differences in labor productivity overall increased by about 14 percentage points from 0.162 in 1970 to 0.299 in 2008, while the contribution of dif-

ferences in capital-labor ratios declined by an almost equal margin of about 14 percentage points from 0.149 to 0.010. In other words, the two moved in opposite directions and more or less offset each other. In contrast, although labor quality differences show a slight declining trend, the change is relatively small compared to the other two factors. (That being said, in 2008, the contribution of differences in labor quality is greater than that of differences in capital-labor ratios.) Thus, given these developments in the three different factors, within-industry differences in labor quality remained largely unchanged between 1970 and 2008.

In other words, over the four decades covered in the analysis, regional differences in capital-labor ratios decreased substantially, thereby greatly contributing to the decrease in prefectural differences in labor productivity. At the same time, however, regional within-industry differences in TPF increased, more or less cancelling out the former effect. This is also shown by the fact that whereas in 1970, the contribution of TFP differences to labor productivity differences, at 25.3%, was more or less the same as that of differences in capital-labor ratios (23.2%), in 2008, with 68.7%, it greatly exceeded the contribution of differences in capital-labor ratios.

Next, let us compare the results obtained here with those in Chapter 5. The aggregate of value added-weighted industry-level TFP differences in this chapter more or less corresponds to the differences in prefecture-level TFP for all industries in Chapter 5. The analysis of prefecture-level TFP differences in Chapter 5 suggested that such differences declined substantially between 1955 and 2008 (Figures 5.1 and 5.2). Moreover, Table 5.1 looking at the dispersion of labor productivity from a cross-section perspective indicated that the contribution of TFP differences declined consistently from 1955 to 2008. On the other hand, Table 6.1 in this chapter suggests that the contribution of within-industry TFP differences to labor productivity differences between the top and bottom 20% of prefectures consistently increased from 1970 onward. The difference in the results for TFP in Chapter 5 and in this chapter are likely due to the following three factors.

The first factor is the difference in periods being analyzed. Because capital stock data by industry are available only from 1970, the starting point for the analysis here is 1970. However, as seen in

Table 5.1, it is between 1955 and 1970, i.e., before the period examined in this chapter, that the largest decline in prefectural TFP differences took place, while the decline between 1970 and 2008 was much more moderate.

The second factor is the choice of prefectures that are being used for the comparison. Table 6.1 in this chapter compares the industry aggregate labor productivity of the top and bottom 20% of prefectures, and Tokyo makes up an overwhelming share of the top 20% of prefectures. Recall that the top 20% of prefectures are chosen based on their cumulative population. Given Tokyo's large share in Japan's population overall, the results in Table 6.1 can be seen as essentially a comparison of Tokyo with prefectures with low labor productivity such as Okinawa, Kagoshima, Yamanashi, and Shimane. On the other hand, the decomposition of the dispersion of labor productivity in Table 5.1 is for all prefectures. Since TFP growth was much higher in Tokyo than in the other prefectures, it is possible that this is the reason that we obtained different results in the two approaches.

The third factor is related to the method of aggregation. If we assume, for example, that the share of industries in which Tokyo's TFP is much higher than that of other prefectures contracts only in Tokyo, prefecture-level TFP differences between Tokyo and the bottom 20% of prefectures would shrink. However, in the decomposition in Table 6.1, such a development would not manifest itself in a change in the contribution of TFP to within-industry labor productivity differences, but in a change in labor productivity differences due to differences in industrial structure. We will return to this issue regarding the method of aggregation later.

Let us summarize the results obtained thus far. Regarding prefectural differences in labor productivity within the same industry, we found that differences in capital-labor ratios worked in the direction of reducing within-industry differences, while TFP differences worked in the opposite direction. As a result, the two more or less cancelled each other out, so that hardly any change in within-industry labor productivity differences was observed. On the other hand, differences in prefectural industrial structures decreased substantially, thus considerably reducing prefectural differences in labor productivity.

The approach employed for the analysis in this section consisted of first decomposing changes in industrial structure and prefectural

within-industry differences and then using information on factor inputs solely for the analysis of prefectural within-industry differences. However, there should also be a close relationship between changes in prefectural industrial structures and factor inputs such that, for example, an increase in capital-intensive industries in a prefecture should push up the capital-labor ratio. The approach in this section does not really allow us to capture such interaction between the industrial structure and the composition of factor inputs. In the next section we therefore use a different approach to examine the relationship between changes in prefectural industrial structures and factor intensities.

6.3 The effect of changes in industrial structure on prefectural differences in factor intensity

The analysis in Chapter 5 using aggregate prefecture-level data suggested that the decline in prefectural differences in the capital-labor ratio was one of the principal driving forces underlying the fall in prefectural differences in labor productivity. Specifically, at the prefectural level, i.e., for all industries together, the capital-labor ratio in the top 20% of prefectures in 1970 was 1.72 times as high as that in the bottom 20% of prefectures, but by 2008 this difference had shrunk to only a factor of 1.02. Moreover, as seen in the preceding section, one of the reasons for this decline in prefectural differences in the capital-labor ratio was the decline in within-industry differences in capital-labor ratios. However, since factor intensities differ substantially across industries, a further reason may have been changes in prefectures' industrial structures. For example, if capital-intensive industries agglomerate in particular prefectures, this will raise the prefecture-level capital-labor ratio of that prefecture. The aim of this section therefore is to examine how changes in prefectures' industrial structure affected their factor intensities. In addition to physical capital-intensity, we will also focus on human capital-intensity.

We start by looking at differences in factor intensity by industry. In contrast with the previous section, in our analysis here, we focus on the 23 industry categories in the R-JIP Database. The national average factor intensities for the 23 industries are presented in Table 6.2.

Table 6.2 shows that factor intensities do indeed differ consider-

ably across industries. Starting with the capital-labor ratio, this is far above the average in the electricity, gas, and water utilities, petroleum and coal products, real estate, chemical, and basic metals industries, while it is more or less in line with the average in the three machinery-related industries (general machinery, electrical machinery, and transport equipment). Meanwhile, it is far below the average in construction, wholesale and retail trade, and other non-government services, which all account for large man-hour shares.[6] These patterns can be observed throughout the period. On the other hand, labor quality does not differ as much across industries as the capital-labor ratio, but a closer look reveals a slight decrease in differences across industries over time.

Next, the man-hour shares in Table 6.2 provide an indication of how Japan's industrial structure overall developed over time. We find that the share of industries with a high capital-labor ratio—such as the petroleum and coal products, chemical, and basic metals industries—has generally declined, although the electricity, gas, and water utilities and real estate industries have seen an increase. On the other hand, the man-hour share of other non-government services, which have a low capital-labor ratio and even in 1970 already accounted for a large share, more than doubled over the roughly four decades covered by our data. Many of the industries with a high capital-labor ratio are what the Japanese call "heavy, high, long, large-type" industries which require space and transport links, so that potential locations for these industries are limited. This is not the case for other non-government services, so that the growth of such services is likely a key factor underlying the decline in differences in prefecture-level capital-labor ratios.

Before examining the effect of structural change on prefectural factor intensities, let us compare the capital-labor ratio, labor quality, and TFP trends between the top and bottom 20% of prefectures.[7] It should be noted that the top and bottom 20% of industries are not

[6] Other non-government services include both "for profit activities" and "not for profit activities" such as entertainment, eating and drinking places, education, and health services.

[7] We conducted a similar analysis for the top and bottom 50% of prefectures. The results are largely the same and are available from the authors on request.

Table 6.2 Capital-labor ratio, labor quality, and man-hour share by industry (national average)

	Capital-labor ratio Capital stock/man hours Unit: Yen (in 2000 prices)/hour			Labor quality Unit: 2000 national average for all industries = 1			Man-hour share Unit: %		
	1970	1990	2008	1970	1990	2008	1970	1990	2008
Agriculture, forestry, and fisheries	1,809	7,140	16,363	0.40	0.63	0.77	16.39	6.83	4.37
Mining	3,206	8,489	18,867	0.78	1.07	0.97	0.47	0.17	0.07
Food and beverages	1,742	4,101	6,885	0.50	0.79	0.90	2.43	2.40	2.40
Textile mill products	1,137	2,293	7,032	0.46	0.70	0.81	3.74	2.48	0.82
Pulp and paper	2,894	6,847	13,928	0.53	0.86	0.95	0.76	0.61	0.44
Chemicals	7,448	16,628	32,716	0.57	0.96	1.06	1.01	0.74	0.66
Petroleum and coal products	27,129	52,522	135,870	0.57	0.99	1.05	0.09	0.06	0.05
Ceramics, stone and clay	2,473	4,592	8,842	0.54	0.89	0.98	1.30	0.97	0.59
Basic metals	5,979	17,650	24,658	0.57	0.95	1.01	2.01	1.10	0.92
Processed metals	1,525	2,373	4,242	0.54	0.88	0.96	2.14	1.96	1.47
General machinery	2,159	4,482	8,615	0.57	0.93	1.03	2.51	2.68	2.50
Electrical machinery	1,497	5,044	14,040	0.49	0.81	1.00	2.62	3.71	2.90
Transport equipment	1,969	9,655	13,108	0.56	0.90	1.00	2.12	2.02	2.36
Precision instruments	915	4,143	12,158	0.50	0.82	0.96	0.53	0.52	0.31
Other manufacturing	1,055	3,185	6,933	0.53	0.86	0.97	5.56	4.87	3.38
Construction	985	1,450	2,384	0.57	0.94	1.05	9.06	10.37	9.32
Electricity, gas and water utilities	35,541	109,985	156,664	0.66	0.98	1.19	0.51	0.62	0.68
Wholesale and retail trade	689	2,574	3,708	0.54	0.89	0.94	16.55	16.12	13.53
Finance and insurance	2,776	3,153	6,610	0.55	0.87	1.01	2.26	3.04	2.98
Real estate	13,705	50,768	68,734	0.78	1.04	1.12	0.59	1.37	1.47
Transport and communications	5,393	14,011	25,888	0.60	0.97	1.08	5.89	6.40	6.53
Other non-government services	1,039	3,599	4,534	0.61	0.99	1.10	16.12	25.34	37.05
Government service activities	3,141	9,315	20,858	0.80	1.25	1.41	5.33	5.63	5.20
Average	2,083	6,184	10,299	0.57	0.94	1.07	—	—	—

ranked in terms of their input factor intensity or TFP level but in terms prefecture-level labor productivity. The results are shown in Table 6.3.[8]

Starting with Table 6.3(a), we find that in 1970 the top 20% of prefectures in terms of prefecture-level labor productivity across all industries had a considerably higher average capital-labor ratio than the bottom 20% of prefectures. However, the relative gap between the two groups shrank over the years, so that by 2008 the capital-labor ratio of the bottom 20% of prefectures no longer lagged far behind that of the top 20%. In fact, looking at individual industries reveals that in capital-intensive industries, the bottom 20% of prefectures in 1970 were already either not far behind the top 20% (petroleum and coal products, basic metals) or even ahead (chemicals; electricity, gas, and water utilities), and that by 2008, they had a higher capital-labor ratio in these industries than the top 20% of prefectures, with the exception of electricity, gas, and water utilities. Moreover, in the real estate industry, the pattern more or less reversed over the roughly four decades: whereas in 1970, the capital-labor ratio in the top 20% was almost twice as high as in the bottom 20%, the opposite was the case in 2008. Further, looking at industries with a comparatively low capital-labor ratio, the relative gap between the two groups shrank considerably over the period or reversed as well (such as the machinery industries and other manufacturing as well as finance and insurance, other non-government services, and government service activities). Overall, therefore, the table shows that whereas in 1970 capital investment tended to be concentrated in prefectures with a high labor productivity overall, by 2008 it had become much more evenly distributed across prefectures.

Turning to Table 6.3(b), we find that, with the exception of the electricity, gas, and water utilities industry, labor quality is higher in the top 20% of prefectures in all industries and years. Finally, Table 6.3(c) for TFP shows that this tends to be higher in the top 20% of prefectures in most industries and on average as well. (The notable exception to this pattern is the average for 1970, which is largely due

[8] It should be noted that we cannot compare TFP across industries, but can only compare TFP within industries between the top and bottom 20% of prefectures or between two points in time.

Table 6.3 Factor-intensity and TFP level of the top and bottom 20% of prefectures

(a) Capital-labor ratio (Unit: Yen (in 2000 prices)/hour)

	1970			1990			2008		
	Top 20%	Bottom 20%	Top/Bottom	Top 20%	Bottom 20%	Top/Bottom	Top 20%	Bottom 20%	Top/Bottom
Agriculture, forestry, and fisheries	2,216	1,631	1.36	12,262	6,408	1.91	12,517	15,491	0.81
Mining	3,378	3,319	1.02	12,622	8,029	1.57	9,883	17,665	0.56
Food and beverages	2,203	979	2.25	4,487	3,223	1.39	6,328	5,647	1.12
Textile mill products	816	851	0.96	1,829	1,672	1.09	3,346	6,992	0.48
Pulp and paper	1,166	3,987	0.29	3,825	12,472	0.31	5,678	18,552	0.31
Chemicals	4,148	7,738	0.54	10,419	20,859	0.50	18,661	34,859	0.54
Petroleum and coal products	19,759	17,448	1.13	31,119	59,844	0.52	97,407	122,120	0.80
Ceramics, stone and clay	2,071	2,190	0.95	5,623	3,463	1.62	6,637	6,965	0.95
Basic metals	4,219	4,160	1.01	16,564	19,458	0.85	19,838	20,085	0.99
Processed metals	1,555	978	1.59	2,367	2,034	1.16	3,616	4,268	0.85
General machinery	1,890	1,622	1.17	4,634	4,077	1.14	5,658	7,634	0.74
Electrical machinery	1,665	988	1.68	5,642	4,266	1.32	8,995	15,036	0.60
Transport equipment	2,313	878	2.63	9,548	5,959	1.60	9,131	9,155	1.00
Precision instruments	1,218	319	3.82	4,214	3,424	1.23	10,218	11,398	0.90
Other manufacturing	1,426	532	2.68	3,251	2,031	1.60	4,635	6,064	0.76
Construction	1,351	866	1.56	1,425	1,218	1.17	2,051	2,327	0.88
Electricity, gas and water utilities	31,272	33,865	0.92	133,048	95,469	1.39	217,715	134,529	1.62
Wholesale and retail trade	1,008	463	2.18	3,199	1,900	1.68	5,246	2,941	1.78
Finance and insurance	3,421	1,712	2.00	3,524	2,234	1.58	7,036	6,187	1.14
Real estate	16,408	7,768	2.11	43,998	63,540	0.69	51,640	97,357	0.53
Transport and communications	8,655	1,838	4.71	18,360	12,199	1.51	32,986	20,665	1.60
Other non-government services	1,630	580	2.81	3,285	3,518	0.93	4,160	4,695	0.89
Government service activities	3,335	2,823	1.18	7,838	9,934	0.79	15,904	23,326	0.68
Average	2,563	1,486	1.72	6,705	5,482	1.22	9,988	9,761	1.02

(b) Labor quality (Unit: 2000 national average for all industries = 1)

	1970			1990			2008		
	Top 20%	Bottom 20%	Top/Bottom	Top 20%	Bottom 20%	Top/Bottom	Top 20%	Bottom 20%	Top/Bottom
Agriculture, forestry, and fisheries	0.50	0.38	1.32	0.71	0.61	1.18	0.87	0.74	1.17
Mining	0.87	0.75	1.15	1.17	1.09	1.07	1.08	1.00	1.08
Food and beverages	0.58	0.46	1.25	0.91	0.73	1.25	1.00	0.84	1.18
Textile mill products	0.52	0.42	1.22	0.81	0.64	1.25	0.91	0.76	1.20
Pulp and paper	0.59	0.48	1.24	0.96	0.79	1.22	1.02	0.92	1.11
Chemicals	0.62	0.51	1.21	1.04	0.86	1.22	1.12	1.00	1.11
Petroleum and coal products	0.62	0.52	1.18	1.07	0.90	1.19	1.11	0.98	1.13
Ceramics, stone and clay	0.60	0.51	1.16	0.97	0.84	1.16	1.08	0.95	1.13
Basic metals	0.61	0.54	1.12	1.02	0.89	1.15	1.07	0.96	1.12
Processed metals	0.57	0.50	1.14	0.95	0.81	1.17	1.01	0.92	1.10
General machinery	0.60	0.53	1.13	1.01	0.86	1.17	1.11	0.98	1.13
Electrical machinery	0.53	0.43	1.24	0.91	0.71	1.28	1.14	0.93	1.23
Transport equipment	0.59	0.55	1.08	0.96	0.85	1.13	1.10	0.96	1.14
Precision instruments	0.54	0.45	1.21	0.93	0.71	1.31	1.05	0.89	1.19
Other manufacturing	0.60	0.47	1.27	0.99	0.76	1.29	1.07	0.91	1.17
Construction	0.62	0.53	1.17	1.02	0.89	1.14	1.11	1.02	1.09
Electricity, gas and water utilities	0.67	0.71	0.95	1.02	0.96	1.06	1.19	1.20	0.99
Wholesale and retail trade	0.60	0.49	1.22	0.97	0.81	1.20	1.02	0.88	1.16
Finance and insurance	0.58	0.55	1.06	0.89	0.85	1.05	1.05	0.98	1.07
Real estate	0.87	0.79	1.09	1.09	0.99	1.10	1.18	1.10	1.07
Transport and communications	0.63	0.59	1.06	1.01	0.95	1.06	1.13	1.04	1.10
Other non-government services	0.68	0.57	1.20	1.06	0.93	1.15	1.16	1.06	1.10
Government service activities	0.89	0.78	1.14	1.35	1.19	1.13	1.50	1.35	1.11
Average	0.63	0.54	1.16	1.02	0.89	1.14	1.13	1.03	1.09

(c) TFP (Unit: 2000 national average in each industry = 1)

	1970			1990			2008		
	Top 20%	Bottom 20%	Top/Bottom	Top 20%	Bottom 20%	Top/Bottom	Top 20%	Bottom 20%	Top/Bottom
Agriculture, forestry, and fisheries	0.87	0.80	1.09	0.66	1.28	0.52	1.11	1.05	1.06
Mining	0.42	0.48	0.88	1.36	0.94	1.44	0.93	0.77	1.20
Food and beverages	1.23	0.89	1.38	1.03	0.78	1.33	0.78	0.73	1.07
Textile mill products	0.73	0.61	1.20	1.18	1.21	0.97	1.45	0.98	1.49
Pulp and paper	0.68	0.53	1.28	1.10	1.14	0.97	0.87	1.07	0.82
Chemicals	0.24	0.12	2.07	1.00	0.67	1.48	1.06	0.83	1.28
Petroleum and coal products	1.32	0.85	1.56	1.20	0.93	1.29	0.98	0.12	7.82
Ceramics, stone and clay	0.77	0.42	1.85	1.00	0.72	1.40	1.27	0.94	1.35
Basic metals	0.62	0.47	1.34	0.93	0.78	1.18	0.81	0.84	0.96
Processed metals	0.55	0.40	1.37	0.85	0.82	1.04	0.79	0.82	0.96
General machinery	0.51	0.38	1.34	1.14	1.01	1.13	1.12	1.36	0.82
Electrical machinery	0.06	0.03	1.82	0.66	0.38	1.74	2.30	2.51	0.92
Transport equipment	0.39	0.24	1.64	0.99	0.63	1.58	1.73	1.21	1.44
Precision instruments	0.43	0.27	1.56	1.09	0.88	1.24	1.10	1.39	0.79
Other manufacturing	0.96	0.68	1.40	1.24	0.95	1.31	1.25	0.94	1.32
Construction	1.12	1.34	0.83	1.42	1.26	1.13	1.15	0.82	1.40
Electricity, gas and water utilities	0.86	0.76	1.14	0.86	1.12	0.76	1.00	1.12	0.90
Wholesale and retail trade	0.40	0.28	1.43	0.83	0.58	1.43	1.38	0.75	1.84
Finance and insurance	0.29	0.27	1.08	1.31	0.73	1.81	0.99	0.61	1.63
Real estate	3.42	13.25	0.26	1.52	1.77	0.86	1.01	1.13	0.89
Transport and communications	0.68	0.92	0.74	0.83	0.91	0.91	1.05	1.15	0.91
Other non-government services	1.20	1.30	0.93	1.28	0.95	1.35	1.31	0.86	1.51
Government service activities	0.94	0.92	1.02	1.01	0.92	1.10	1.31	1.13	1.16
Average	0.63	0.65	0.97	1.07	0.89	1.20	1.23	0.93	1.31

to the extremely high TFP value in the real estate industry of the bottom 20% of prefectures. This, in turn, likely is a statistical artefact. In this period, large real estate companies from major cities such as Tokyo were setting up branches in rural prefectures to oversee major real estate investment projects in these prefectures in anticipation of high-speed rail links and other transportation infrastructure improvements. In this case, service input from headquarters is not properly counted in the estimation of local branches' value added, thus overstating their TFP.)

Let us now turn to the examination of the link between prefectures' industrial structure and factor intensities. To do so, we use the following equation to decompose the difference between the capital-labor ratio in prefecture r and the national average of the capital-labor ratio (i.e., the left-hand side of the equation) into the part due to differences in prefectures' industrial structure (the first term on the right-hand side of the equation) and the part due to prefectural differences in factor inputs within the same industry (the second term on the right-hand side of the equation):[9]

$$\sum_{i=1}^{I} l_{i,r} z_{i,r} - \sum_{i=1}^{I} \bar{l}_i \bar{z}_i \approx \sum_{i=1}^{I} (l_{i,r} - \bar{l}_i)(\bar{z}_i - \bar{\bar{z}}) + \sum_{i=1}^{I} (z_{i,r} - \bar{z}_i) \bar{l}_i . \tag{6.6}$$

Equation (6.6) allows us to do the following. If we find, for example, that the capital-labor ratio of prefecture r is higher than the national average, we can decompose this difference into the sum of two effects: the fact that prefecture r has a high concentration of industries with a high capital-labor ratio; and the fact that the capital-labor ratio in many industries in prefecture r is higher than the national average for those industries We will refer to the former as the share effect and to the latter as the within effect.[10]

Based on this approach, Table 6.4 shows the decomposition of the differences in prefectures' capital-labor ratios, labor quality, and TFP from the national average into the share effect and the within effect for the top and bottom 20% of prefectures in terms of labor productivity for 1970, 1990, and 2008. Note that (as mentioned in footnote 8) it is not possible to compare TFP levels across industries, so that in the

case of TFP we can only calculate the within effect, but not the share effect. Therefore, for TFP, the difference from the average for Japan shown in Table 6.4 captures only the within effect.

The results in the table show that the difference in the capital-labor ratios between the top and bottom prefectures declined rapidly during our observation period (from 51.7 percentage points in 1970 to 19.7 percentage points in 1990 and 2.2 percentage points in 2008), so that by 2008 the difference had almost disappeared. Moreover, we find that at the beginning of our observation period in 1970 most of the difference in capital-labor ratios was due to the within effect, while the share effect played only a minimal role. Consequently, the contribution of the share effect to the decline in the difference in the capital-labor ratio was also small and it was primarily the within effect that drove

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[9] Equation (6.6) is derived as follows. The prefecture-level capital-labor ratio (i.e., for all industries together) in a prefecture, z_r, can be represented as the weighted average of the capital-labor ratio in each industry, $z_{i,r}$, where the weights are given by industries' labor input share $v^L_{i,r}$ measured in terms of man-hours:

$$k_r \equiv \sum_{i=1}^{I} v^L_{i,r} z_{i,r} .$$

Next, the national average of the capital-labor ratio in industry i, denoted by $\bar{z}_i$, and the national average of the labor input share in that industry, denoted by $\bar{l}_i$, are obtained by taking the simple average across all prefectures:

$$\bar{z}_i \equiv \frac{1}{47} \sum_{r=1}^{47} z_{i,r}, \quad \bar{l}_i \equiv \frac{1}{47} \sum_{r=1}^{47} l_{i,r} .$$

Further, the capital-labor ratio for Japan as a whole across all industries, denoted by $\bar{z}$, is obtained as the weighted average of the national average capital-labor ratio in each industry, z_i, using the national average labor input share in each industry, $\bar{l}_i$, as weights:

$$\bar{z} \equiv \sum_{i=1}^{I} \bar{l}_i \bar{z}_i .$$

The difference between the capital-labor ratio for each prefecture as a whole and the capital-labor ratio for Japan as a whole can then be decomposed as shown below by regarding the product $l_{i,r} z_i$ as a non-linear function of $l_{i,r}$ and $z_{i,r}$ and linearly approximating in the neighborhood of $l_{i,r} = \bar{l}_i$ and $z_{i,r} = \bar{z}_i$:

the overall trend.

Turning to the results on labor quality, it is again the within effect that was more important than the share effect. However, because the decline in the within effect was less pronounced than in the case of the capital-labor ratio, the difference in labor quality in 2008 between the top and bottom prefectures when adding up the two effects was still about 9 percentage points, meaning that the difference was larger than that for the capital-labor ratio. Finally, the difference in TFP between the top and bottom prefectures increased throughout the period and in 2008 stood at about 27 percentage points.

Comparing the results in Table 6.4 with those in the preceding section, the share effect and the within effect can be considered to respectively correspond to the contribution of differences in industrial structure and the contribution of within-industry differences in labor productivity. The analysis in this section showed that over the four

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$$\sum_{i-1}^{I} l_{i,r}z_{i,r} - \sum_{i=1}^{I} \bar{l}_i\bar{z}_i \approx \sum_{i=1}^{I} (l_{i,r}-\bar{l}_i)\bar{z}_i + \sum_{i=1}^{I} (z_{i,r}-\bar{z}_i)\bar{l}_i$$

$$= \sum_{i=1}^{I} (l_{i,r}-\bar{l}_i)(\bar{z}_i-\bar{z}) + \sum_{i=1}^{I} (l_{i,r}-\bar{l}_i)\bar{z} + \sum_{i=1}^{I} (z_{i,r}-\bar{z}_i)\bar{l}_i .$$

Given that the second term on the right-hand side equals zero, we obtain the following relationship (where we use the fact that the sum total of the labor input shares in each prefecture has to be equal to 1):

$$\sum_{i=1}^{I} l_{i,r}z_{i,r} - \sum_{i=1}^{I} \bar{l}_i\bar{z}_i \approx \sum_{i=1}^{I} (l_{i,r}-\bar{l}_i)(\bar{z}_i-\bar{z}) + \sum_{i=1}^{I} (z_{i,r}-\bar{z}_i)\bar{l}_i ,$$

where the first term on the right-hand side represents the contribution of the fact that a prefecture has, e.g., above-average labor input shares in industries with a capital-labor ratio that is above the national average, while the second term represents the contribution of differences between the capital-labor ratios of the industries in a particular prefecture and the national average capital-labor ratios for those industries.

[10] Note that definitions of the "share effect" and "within effect" here differ from those used in Section 6.4, where we focus on each industry's contribution to the covariance between the two terms on the right-hand side of equation (6.6) and labor productivity in each of the prefectures.

Table 6.4 Decomposition of prefecture-level factor input differences between the top and bottom 20% of prefectures

(a) 1970

	Top 20%	Bottom 20%	Japan average
Capital-labor ratio (Unit: Yen (in 2000 prices)/hour)	2,563	1,486	2,083
Difference from Japan average (%)	23.1	−28.6	
Share effect	4.1	−5.1	
Within effect	18.9	−29.1	
Approximation error	0.1	5.6	
Labor quality (Unit: 2000 national average for all industries = 1)	0.63	0.54	0.57
Difference from Japan average (%)	9.3	−5.6	
Share effect	0.0	0.4	
Within effect	10.0	−15.6	
Approximation error	−0.7	9.7	
TFP (Unit: 2000 = 1)	0.63	0.65	0.65
Difference from Japan average (%)	−2.2	1.3	

(b) 1990

	Top 20%	Bottom 20%	Japan average
Capital-labor ratio (Unit: Yen (in 2000 prices)/hour)	6,705	5,482	6,184
Difference from Japan average (%)	8.4	−11.3	
Share effect	4.6	−4.4	
Within effect	9.3	−5.9	
Approximation error	−5.5	−1.0	
Labor quality (Unit: 2000 national average for all industries = 1)	1.02	0.89	0.94
Difference from Japan average (%)	8.1	−5.1	
Share effect	0.1	1.0	
Within effect	8.2	−8.1	
Approximation error	−0.2	2.1	
TFP (Unit: 2000 = 1)	1.07	0.89	1.00
Difference from Japan average (%)	7.0	−11.1	

(c) 2008

	Top 20%	Bottom 20%	Japan average
Capital-labor ratio (Unit: Yen (in 2000 prices)/hour)	9,988	9,761	10,299
Difference from Japan average (%)	−3.0	−5.2	
Share effect	0.1	−1.9	
Within effect	−4.0	−2.1	
Approximation error	0.9	−1.2	
Labor quality (Unit: 2000 national average for all industries = 1)	1.13	1.03	1.07
Difference from Japan average (%)	5.7	−3.4	
Share effect	−0.5	1.0	
Within effect	6.6	−5.0	
Approximation error	−0.3	0.7	
TFP (Unit: 2000 = 1)	1.23	0.93	1.08
Difference from Japan average (%)	13.1	−13.8	

decades that we focus on, within-industry differences in capital-labor ratios tended to decline and within-industry differences in TFP tended to increase, which is more or less consistent with the result in the preceding section based on decomposing prefectural within-industry differences in labor productivity into the contribution of the capital-labor ratio, labor quality, and TFP. On the other hand, the factor decomposition in the preceding section indicated that differences in industrial structure made a considerable contribution to prefectural labor productivity differences, whereas the analysis in this section on prefectural differences in capital-labor ratios and labor quality suggests that the share effect did not play a particularly large role. Since the decomposition equation employed for the analysis in this section does not allow us to calculate the share effect for TFP, we therefore suspect that there must be a share effect with regard to TFP that we were not able to pick up. Returning to the example given above, if the share of industries in which Tokyo has a much higher TFP than other prefectures contracts in Tokyo, the difference in aggregate TFP for all industries between Tokyo and the bottom 20% of prefectures would decline. However, this kind of effect is not included in the change in the TFP contribution in Table 6.4. How to measure this TFP share effect is an issue that we have to leave for future research.

The analytical approach in this section allowed us to break down factor inputs into the capital-labor ratio, labor quality, and TFP and decompose prefectural differences in these into the contribution of the share effect and the industry effect. However, in order to understand how the growth or decline of individual industries contributed to developments in labor productivity differences, and trends in which industries made the largest contribution, a different approach is necessary. The next section seeks to tackle this issue by examining the correlation between the share and industry effects obtained in this section and differences in prefecture-level aggregate labor productivity.

6.4 Industry contributions to the decline in regional differences in labor productivity

Examining how prefectural differences in industrial structure give rise to differences in prefectural labor productivity, the analysis so far highlighted two mechanisms: the share effect and the within effect.

The first referred to the fact that if, for example, the share of industries with an above-average capital-labor ratio increases in a prefecture, the capital-labor ratio for the prefecture as a whole and, as a result, labor productivity will increase. On the other hand, the second referred to the fact that if the capital-labor ratio in a particular industry in a prefecture rises relative to the capital-labor ratio in that industry in other prefectures, this will also result in an increase in the capital-labor ratio and hence in labor productivity. In this section, we investigate the contribution of each of the different industries to these two effects. It should be noted that whereas in the previous sections we focused on differences between the top and bottom 20% of prefectures, for this analysis we examine differences in factor intensity and productivity across all prefectures.

We do so by first taking the covariance between the left-hand side of equation (6.6) and prefecture-level labor productivity, y_r, that is, the covariance between prefecture-level capital intensities relative to the national average and prefecture-level labor productivities. This covariance can be decomposed using the right-hand side of equation (6.6). The calculation is shown in the following equation:

$$Cov\left(\sum_{i=1}^{I} l_{i,r}z_{i,r} - \sum_{i=1}^{I} \bar{l}_i\bar{z}_i, y_r\right)$$
$$= \sum_{i=1}^{I} Cov((l_{i,r}-\bar{l}_i)(\bar{z}_i-\bar{z}), y_r) + \sum_{i=1}^{I} Cov((z_{i,r}-\bar{z}_i)\bar{l}_i, y_r).$$

In the right-hand side of the above equation, the first term is the sum of the covariances between the share effect of each industry and prefectures' labor productivity, while the second term is the sum of the covariances between the within-effect of each industry and prefectures' labor productivity.

Next, we divide the covariance for each industry in the first term on the right-hand side by the total covariance between prefecture-level capital intensities and labor productivity levels:

$$\frac{Cov((l_{i,r}-\bar{l}_i)(\bar{z}_i-\bar{z}), y_r)}{\sum_{i=1}^{I} Cov((l_{i,r}-\bar{l}_i)(\bar{z}_i-\bar{z}), y_r) + \sum_{i=1}^{I} Cov((z_{i,r}-\bar{z}_i)\bar{l}_i, y_r)}.$$

We refer to this as the contribution of the share effect for industry i.

Similarly, we divide the covariance for each industry in the second term by the total covariance between prefecture-level capital intensities and labor productivity levels.

$$\frac{Cov((z_{i,r}-\bar{z}_i)\bar{l}_i, y_r)}{\sum_{i=1}^{I} Cov((l_{i,r}-\bar{l}_i)(\bar{z}_i-\bar{z}), y_r)+\sum_{i=1}^{I} Cov((z_{i,r}-\bar{z}_i)\bar{l}_i, y_r)}.$$

We refer to this as the contribution of the within effect for industry i.

Similarly, regarding labor quality and TFP, we can decompose the difference between prefecture r's labor quality or TFP and the average for Japan as a whole as in equation (6.6). The only difference is that, for labor quality, we use not the man-hour share but the labor cost share, while for TFP, we use the nominal value added share. Just as in the case of the capital-labor ratio, we follow the same procedure to calculate the contribution of the share effect and the within effect to the total covariance between prefecture-level labor quality or TFP and labor productivity levels. The results for 1970, 1990, and 2008 are shown in Table 6.5.

Let us start by looking at the results for the capital-labor ratio. In the manufacturing sector, the share effect was positive throughout the observation period in the heavy and chemical industries, whereas it was negative in the machinery industries. This shows that the capital-intensive heavy and chemical industries are concentrated in prefectures with high prefecture-level labor productivity, and that the machinery industries, which are not very capital-intensive, are not necessarily concentrated in prefectures with high labor productivity. Turning to the within-industry effect, this is generally positive in all industries with the exception of the large negative value for the contribution of the electrical machinery industry in 2008, and we find that in prefectures with a higher prefecture-level labor productivity, the capital-labor ratio of manufacturing industries tends to be higher than within the same industry in other prefectures. For the service sector, we find that the share effect overall made a large positive contribution, although in government services it made a large negative contribution. A notable development is that the share effect increased greatly over time in the real estate and transport and communications

Table 6.5 Industries' contribution to the decline in prefectural labor productivity differences

(a) 1970

	Capital-labor ratio		Labor quality		TFP
	Share effect	Within effect	Share effect	Within effect	Within effect
Agriculture, forestry, and fisheries	−0.18	6.60	30.30	26.72	4.33
Mining	−0.71	−0.09	−10.22	3.46	2.30
Food and beverages	0.14	3.04	−0.35	4.53	12.91
Textile mill products	−1.37	1.87	−1.37	7.22	8.07
Pulp and paper	0.30	−1.27	0.57	1.35	1.25
Chemicals	5.48	2.77	6.81	2.00	13.43
Petroleum and coal products	4.28	0.15	1.07	0.14	9.28
Ceramics, stone and clay	0.18	0.96	0.77	2.04	4.32
Basic metals	6.05	3.92	14.86	1.91	0.00
Processed metals	−0.85	1.09	3.90	1.73	3.74
General machinery	0.67	1.59	9.65	2.07	7.60
Electrical machinery	−1.22	1.07	1.04	5.12	6.36
Transport equipment	−1.11	1.26	8.55	1.50	5.81
Precision instruments	−0.30	0.23	0.22	0.57	0.29
Other manufacturing	−2.13	3.61	5.01	8.99	3.55
Construction	−0.50	1.91	4.01	13.48	8.81
Electricity, gas and water utilities	1.01	5.00	−2.19	−4.05	2.39
Wholesale and retail trade	−1.01	3.25	−2.93	23.23	19.86
Finance and insurance	0.23	2.31	1.08	−4.37	0.80
Real estate	2.73	1.61	2.71	−1.84	−5.73
Transport and communications	2.29	33.69	−4.70	−0.65	−10.08
Other non-government services	−0.31	9.94	−16.62	17.25	3.38
Government service activities	−1.89	3.70	−73.92	9.37	−2.69
Primary sector subtotal	−0.89	6.51	20.08	30.18	6.63
Manufacturing subtotal	10.12	20.30	50.72	39.16	76.61
Services subtotal	2.54	61.42	−92.57	52.42	16.76
Total	11.77	88.23	−21.76	121.76	100.00

industries. The within effect in the service sector generally tended to decline, with particularly pronounced falls seen in the real estate industry and government services, so that the contribution in the service sector overall fell by about half from 1970 to 2008.

Next, looking at the results for labor quality, we find that, as in the case of the capital-labor ratio, the share effect in the manufacturing sector is positive in many industries, indicating that human capital-intensive industries are concentrated in prefectures with high labor productivity. The results further show that labor quality in agriculture, forestry, and fisheries is comparatively low, and because these activities are concentrated in prefectures with low labor productivity, the share effect is positive and considerable, although it fell substan-

(b) 1990

	Capital-labor ratio		Labor quality		TFP
	Share effect	Within effect	Share effect	Within effect	Within effect
Agriculture, forestry, and fisheries	−7.96	20.33	13.35	8.06	−15.93
Mining	−0.46	1.06	−1.64	0.80	0.40
Food and beverages	0.98	2.21	−0.09	4.49	10.57
Textile mill products	1.16	2.00	0.18	4.44	3.61
Pulp and paper	0.07	−0.89	0.33	1.29	0.76
Chemicals	5.17	2.62	5.06	2.01	11.96
Petroleum and coal products	2.38	0.56	0.82	0.17	0.76
Ceramics, stone and clay	0.11	1.12	0.02	1.92	4.00
Basic metals	6.06	2.96	6.43	2.21	−0.67
Processed metals	−2.76	0.41	2.57	2.36	2.32
General machinery	−1.83	1.35	6.69	4.02	6.01
Electrical machinery	−0.11	0.59	0.38	9.09	10.34
Transport equipment	0.67	3.22	5.32	2.46	7.54
Precision instruments	0.05	0.37	0.01	1.05	1.40
Other manufacturing	−3.38	4.53	3.57	8.49	4.52
Construction	1.91	2.01	−0.64	9.28	13.69
Electricity, gas and water utilities	0.20	7.55	−1.40	0.24	−4.55
Wholesale and retail trade	0.91	8.02	−3.88	13.25	23.83
Finance and insurance	−1.04	1.23	0.22	0.00	9.52
Real estate	27.60	−7.60	2.73	−1.00	−2.02
Transport and communications	4.34	12.08	0.60	0.64	−1.68
Other non-government services	−2.23	5.10	−6.50	18.09	14.44
Government service activities	−2.28	−0.38	−39.09	11.58	−0.83
Primary sector subtotal	−8.42	21.40	11.72	8.86	−15.52
Manufacturing subtotal	8.56	21.05	31.29	44.00	63.14
Services subtotal	29.41	28.01	−47.95	52.08	52.39
Total	29.55	70.45	−4.94	104.94	100.00

tially in 2008. On the other hand, labor quality in government services is high, and because government services are concentrated in prefectures with low productivity, the share effect is large and negative, i.e., the opposite to agriculture, forestry, and fisheries. Turning to the within effect, this is positive in almost all industries, showing that the higher prefectural labor productivity within a particular industry is compared to the same industry in other prefectures, the more human capital-intensive is that industry.

Finally, let us look at the results for TFP. Again, due to data limitations, we can only look at the within effect. We find that for 1970, the TFP within effect is generally positively correlated with prefectural labor productivity. Exceptions are the real estate and transport and communications industries as well as government services, where the correlation was negative, and these were joined in the following four

(c) 2008

	Capital–labor ratio		Labor quality		TFP
	Share effect	Within effect	Share effect	Within effect	Within effect
Agriculture, forestry, and fisheries	−30.47	13.10	7.07	4.92	−7.18
Mining	−1.05	1.37	−0.27	0.73	−0.07
Food and beverages	2.95	5.30	−0.19	5.09	7.01
Textile mill products	0.39	3.35	0.13	2.07	0.00
Pulp and paper	0.28	−2.62	0.22	0.87	0.57
Chemicals	11.85	6.32	5.28	1.93	1.25
Petroleum and coal products	5.67	2.99	0.78	0.20	13.43
Ceramics, stone and clay	−0.01	1.29	0.15	1.33	2.59
Basic metals	6.19	7.13	3.89	2.47	1.81
Processed metals	−3.82	0.62	1.67	2.05	0.97
General machinery	−1.93	3.72	6.06	5.31	3.77
Electrical machinery	−2.26	−10.52	−1.02	10.90	−0.95
Transport equipment	−1.09	5.52	6.64	4.69	6.84
Precision instruments	0.00	0.45	0.03	0.96	−0.30
Other manufacturing	−4.00	7.42	3.75	6.55	1.95
Construction	9.28	1.10	−5.43	7.10	11.72
Electricity, gas and water utilities	−8.78	24.96	−3.24	−1.42	−2.57
Wholesale and retail trade	−1.69	8.43	0.77	13.63	25.27
Finance and insurance	−1.71	1.07	0.96	0.91	8.12
Real estate	54.77	−15.92	3.39	−1.81	−0.64
Transport and communications	11.82	21.76	4.72	2.97	0.87
Other non-government services	−5.72	−2.31	−5.23	36.71	25.09
Government service activities	−13.27	−11.96	−62.59	24.28	0.44
Primary sector subtotal	−31.51	14.48	6.80	5.65	−7.25
Manufacturing subtotal	14.23	30.99	27.40	44.43	38.95
Services subtotal	44.70	27.13	−66.65	82.37	68.29
Total	27.41	72.59	−32.45	132.45	100.00

decades by agriculture, forestry, and fisheries and parts of the manufacturing sector. Nevertheless, in the majority of industries, the correlation between the TFP of those industries and prefectural labor productivity is positive. Moreover, the relative shares of the manufacturing and service sectors in the covariance for all industries more or less reversed over the roughly four decades examined, with the share of the manufacturing sector falling from about 77% in 1970 to 39% in 2008 and that of the service sector increasing from 17% to 68%.

As highlighted by, for example, Fujita and Tabuchi (1997), from the 1970s onward, Japan's industrial structure changed from one dominated by the heavy and chemical industries to one dominated by high-tech and service industries. They further pointed out that this change in industrial structure led economic activity in Japan to become heavily concentrated in Tokyo. Our analysis confirms this pat-

tern, indicating that physical capital-intensive service industries such as real estate and transport and communications are concentrated in prefectures with high labor productivity, and that human capital-intensive service industries such as other non-government services and transport and communications are also concentrated in prefectures with high labor productivity, with Tokyo first among them. These factors are the main reason for the remaining differences in prefectural labor productivity. Looking at the correlation between TFP and prefectural labor productivity, we find that non-manufacturing industries such as construction, wholesale and retail, and other non-government services make a particularly large contribution to the remaining differences in labor productivity across prefectures.

On the other hand, in the manufacturing sector, the share effect of labor quality and the within effect of TFP have declined markedly. Specifically, we found that in the manufacturing sector prefectural labor productivity differences declined through the growing concentration of human capital-intensive industries in non-metropolitan regions and the relocation of factories with high within-industry TFP toward such regions.

It should be noted, however, that when interpreting the results reported above, we need to be careful when considering the direction of causality involved in the contribution of individual industries to prefectural differences in labor productivity. For instance, the fact that prefectures with high labor productivity have a higher concentration of physical and human capital-intensive industries could reflect that such prefectures had more abundant physical and human-capital resources to start with and, based on the Heckscher-Ohlin mechanism, specialized in physical and human capital-intensive industries.[11]

[11] Empirical studies that support the Heckscher-Ohlin interpretation of regional specialization include those by Kim (1995) and Yue (1998). The Heckscher-Ohlin model explains regional specialization in terms of differences in regions' factor endowments. Kim (1995) finds that the long-run trends in US regional specialization support explanations based on the Heckscher-Ohlin model and are inconsistent with explanations based on external economies. Yue's (1998) analysis focusing on Japan finds that regional specialization in Japan can be explained by factor endowments in line with the Heckscher-Ohlin model, although in the last years of his analysis factor endowments seem to have played a diminishing role.

On the other hand, because of high domestic factor mobility, the regional distribution of production factors is determined endogenously, so that the distribution of industries depends on a variety of factors. These include firms' locational choices reflecting, for instance, agglomeration effects and factor prices, transportation costs of inputs and outputs, and infrastructure. They also include changes in Japan's comparative advantage over time; for example, Japan's comparative advantage in the transportation machinery industry resulted in the agglomeration of that industry in Aichi prefecture. And they include changes in Japan's industrial structure overall through, for instance, the shift to a post-industrial economy and through population aging, which does not affect all regions in the same way, so that sectors such as the healthcare industry expand much more in some prefectures than in others. Under these circumstance, physical and human capital will move to prefectures where physical and human capital-intensive industries are concentrated, so that the labor productivity of these prefectures will increase relative to that of other prefectures.

Given the high factor mobility in Japan during the post-war period, it can be conjectured that probably the latter mechanism was more important than the former; that is, Japan's industrial structure likely determined the distribution of factors of production rather than the other way around. However, to confirm this, further empirical analysis from a spatial economics perspective focusing on the location of firms and the advantages of agglomeration is necessary. Unfortunately, such an analysis is beyond the scope of the current study, but we hope to conduct further research on this issue using the R-JIP Database in the future.[12]

6.5 Conclusion

Using the R-JIP Database, this chapter examined prefectural differences in labor productivity from 1970 to 2008 from various angles by looking at prefectural differences in industrial structure and prefectural and industry differences in factor inputs and productivity. In Section 6.2, we decomposed prefectural labor productivity differences into

[12] In fact, research along these lines is already underway, with Ikeuchi et al. (2013) partly addressing this issue.

the contribution of differences in industrial structure and the contribution of within-industry differences in labor productivity, and further decomposed the latter into the contribution of the capital-labor ratio, labor quality, and TFP. The results indicated that, during the roughly four decades, prefectural differences in labor productivity declined and that most of this decline is explained by the decline in differences in industrial structure. On the other hand, within-industry labor productivity differences played a minor role, since the decline in regional differences in capital-labor ratios and the increase in regional differences in TFP more or less cancelled each other out.

Next, in Section 6.3, we decomposed prefectural differences in productivity and factor inputs into the share effect due to prefectural differences in industrial structure and the within effect due to prefectural differences in productivity or factor intensity within the same industry. The results showed that much of the difference in prefectural capital-labor ratios and labor quality in 1970 can be explained by the within effect and that the largest part of the decline in prefectural differences in capital-labor ratios during the subsequent four decades is also explained by the within effect.

Finally, in Section 6.4 we examined which industries make the largest contribution to prefectural differences in productivity and how—that is, through differences in the capital-labor ratio, labor quality, or TFP, and through the share effect or the within effect. For this analysis, we decomposed the covariance between prefectures' capital-labor ratio and their labor productivity into the covariance for each industry, which was further decomposed into the share effect and the within effect. Moreover, we applied the same approach to examine the role of labor quality and TFP. We found that no clear pattern for the 23 industries can be observed, with the share and within effects of factor intensities showing positive correlations with prefectural labor productivity in some cases and negative correlations in others. However, for the manufacturing sector as a whole and for the service sector as a whole, we find that both the share and within effects of factor intensities show generally positive correlations with prefectural labor productivity, with the share effect for labor quality in the service sector being the only exception. In other words, the broad pattern is that prefectures with a high share of industries that have a high capital-labor ratio, high labor quality, and high TFP relative to the national

average for those industries and prefectures have higher labor productivity than other prefectures. The only result that does not fit this pattern is that the share effect of labor quality in the service sector is negative in all years. The main reason for this result is that labor quality in government service activities is high and prefectures in which government service activities account for a large share of economic activity also tend to be the prefectures in which there is relatively little private sector activity and labor productivity is low.

Overall, the results from the three different analyses are generally consistent with each other. However, one puzzle remains, which is that Section 6.2 suggested that almost all of the decline in prefectural labor productivity differences since 1970 can be explained by the decline in differences in industrial structure, while the analysis in Section 6.3, which focused on prefectural differences in factor inputs, indicated that the share effect, which can be thought of as being caused by prefectural differences in industrial structure, had very little explanatory power. As pointed out in that section, due to data limitations we cannot grasp the share effect of TFP. Whether it is possible to resolve this remaining puzzle by figuring out a way to measure the share effect with regard to TFP is a task we would like to tackle in the future.

Chapter 7

Conclusion

Japan can be regarded as a success story in economic development not only due to the substantial increase in living standards achieved since the late 19th century, but also due to the way that economic progress spread throughout the country. Other countries also experienced spectacular economic growth in the 20th century, but in most cases this was associated with some kind of regional divide, such as the north–south divide in Italy and Spain, the two other lower-income countries of the late 19th century that experienced a phase of high-speed growth in the 1950s and 1960s and managed to gradually catch up with the living standards of leading OECD countries in the 1980s and 1990s, or the polarization in the location of high value added activities between the capital city and the rest of the country, as in France and South Korea. Moreover, although the gross value added in a number of manufacturing sectors in regions that were industrial powerhouses in the late 19th and early 20th has decreased in relative or absolute terms, such regions did not experience a decline comparable to the one observed in the former industrial core regions of Britain, Germany, and the United States, which suffered deindustrialization, high unemployment, and demographic decline.

Using our long-term data on per capita GPP, industrial structure, sectoral employment, and labor productivity, we examined how regional income inequality in Japan evolved over time and what the main engines of regional divergence and convergence were. Although

our study, due to space limitations, mostly focused on a quantitative analysis, where possible we attempted to discuss the role of institutional change, technological change, and external shocks, and to provide examples of economic activities that played a major role in the development of regional specialization and contributed to the emergence of Japan as a major manufacturing power. Rather than summarizing the results obtained in the different parts of the volume (such summaries are already provided in the conclusions of the different chapters), this chapter seeks to synthesize the results and discusses the main drivers of convergence or divergence.

The results obtained in the different chapters suggest that there have been four main driving forces determining economic convergence in Japan: changes in industrial structure, domestic migration, public polices, and technology diffusion.

Changes in industrial structure appear to have been one of the most important drivers throughout. During the Tokugawa period, that is, before the onset of modern economic development, urbanization receded but proto-industrialization spread throughout the country from the 18th century to the start of the Meiji period (Saito, 2008). These factors contributed to the relatively low income gaps across regions at the beginning of our observation period in 1874. One major reason for the increase in regional inequality that we observed after 1874 likely was the end of restrictions on international trade as a result of the unequal treaties forced on Japan in 1858, with Japan regaining full tariff autonomy only in 1911 (Perez, 1999). As the imposed tariff rates for most imports were extremely low, local cottage industries such as the cotton, salt, paper, and wax candle industries were almost wiped out. Agricultural regions and cottage industry districts specialized in these products became major losers of the opening up to international trade. In other words, since these industries were not scattered evenly across the country, the liberalization of international trade represented an asymmetric shock.

There were, however, also some winners, chief among them the silk industry, which benefited from rapidly growing demand for silk products in the United States. Equally important was access to information on western technology, which Japanese producers managed to adapt to local conditions taking into account relative factor price (Ma, 2004). The combined effects of the decline in cotton production, which

was located mainly in western Japan, and the expansion of the silk industry helped to reduce the income gap between western and eastern Japan.

Some traditional industries were successful in modernizing. The abolishment of regulations on inter-regional trade and migration resulting from the Meiji Restoration of 1868 increased competition among Japanese cottage industry producers, which tended to lead to greater specialization in a number of industrial districts. In geographical terms, there were both winners and losers. Agglomeration effects further reinforced specialization, while the increased mobility of skilled and unskilled workers reinforced the geographical concentration of activities.

At the same time, the importation of Western technology allowed the creation and development of new enterprises specialized in the production of consumer goods such as matches, paper, and cigarettes, as well as capital and intermediate goods in metal processing, machinery, and chemical industries that had been initially imported from Europe. But the most important success story in import substitution is that of cotton yarn following the establishment of the Osaka Cotton Spinning Company in 1882. These new industries tended to cluster in a few port cities such as Kobe, Osaka, and Yokohama. Most traditional industries were labor intensive, so that until 1890 average labor productivity in the manufacturing sector overall was more or less the same as in the primary sector. However, in the new industrial districts, labor productivity forged ahead, contributing to the divergence observed between 1874 and 1890.

In developments in regional inequality after 1874, the role of services should not be overlooked. Wholesale trade activities were very profitable from the early Meiji period to the late 19th century. This and the growing employment share of wholesale activities, which were concentrated in large cities, also seem to have contributed to the divergence observed during this period. However, the labor productivity gap between the commerce sector and other sectors diminished over time as the decline in price differences across regions eroded a major source of profits in the commerce sector, the introduction of new technologies and capital deepening increased labor productivity in the manufacturing sector, and the commerce sector absorbed excess labor from lower income regions and lower income sectors such as

agriculture during the inter-war period. As a result of these developments, prefectural differences in service sector per capita value added, which had been considerable at the start of our observation period, steadily declined.

From around the turn of the 20th century, manufacturing came to play an increasingly prominent role. During the first three decades of the 20th century, the growth of capital-intensive manufacturing industries such as metal processing and machinery contributed to the rise of per capita income in new industrial cores such as Kanagawa, Aichi, and Fukuoka prefectures. Examples include important ammunition factories provisioning the navy located in Yokosuka (Kanagawa), Sasebo (Nagasaki) and Kure (Hiroshima), and for the army in Kokura (Fukuoka) and Nagoya (Aichi). These activities also affected regional inequality as Japan expanded its production of military equipment during the First Sino-Japanese War, the Russo-Japanese War, World War I, and even more so from 1937 to 1945 as a consequence of the Second Sino-Japanese War and the Pacific War. Each of these military conflicts increased the demand for manufactured goods and became one of the most powerful determinants of the success of import substitution. Industrial activities related to military demand were initially restricted to shipbuilding, machinery, and leather and apparel (in particular uniforms). But the scope rapidly expanded to chemicals (explosives), telecommunication and optical equipment (first for the army and navy and then increasingly for the air force), as well as automotive and aeronautic products. This led in turn to demand for special metals that played a critical role in the development of electrometallurgy. Thus, not only did the military, as shown by Samuels (1996), play an important role in the development of high-tech industries in Japan, it also—through its demand—shaped the regional pattern of development.

Following World War II, the retreat from China and Korea reduced the advantage of the main industrial areas of western Japan such as Fukuoka and Osaka (Nakajima, 2008), which had also been the major commercial hubs outside the Kanto region. In parallel, the importance of trade with the United States increased the advantage of coastal prefectures of eastern Japan, where the main international commercial harbors were located, in particular Tokyo and Chiba, but also Kanagawa and Aichi.

From the late 1960s, in the context of rising labor costs and a relative shortage of labor in major urban areas as well as the introduction of strict regulations against environmental pollution in urban areas, manufacturing firms relocated their factories from cities to rural Japan. This spatial diffusion greatly contributed to regional convergence. Finally, from the 1980s, the manufacturing sector, which had been the main engine of convergence during the period 1970–1990, started to relocate activities abroad. The importance of city-type service industries such as real estate and communication increased. These factors slowed down the convergence process. In sum, it can be said that more or less throughout Japan's modern economic history, changes in industrial structure have been an important driver of divergence or convergence.

The second important determinant of developments in regional inequality, generally working in the direction of convergence, was domestic migration. Following the Meiji Restoration, Japan experienced migration from poorer to wealthier regions on a massive scale, except during World War II, and although the number of workers in agriculture did not decline substantially during the pre-war period, this contributed to regional convergence, both before and after World War II. At the same time, this migration, which accelerated during the high-speed growth era from 1955 to 1973, is also responsible for the present problems of depopulation and aging in poorer regions of Japan. More recently, the pace of migration has slowed as a result of the decline in regional income gaps as well as the decline in the number of second and third children, and this has contributed to the slowdown in convergence. No evidence of a brain drain can be found, at least for the post-war period. Rather, the gap in education levels across regions that we found were the result of the fact that children in wealthier prefectures tended to receive more education.

Public policies appear to have been the third important driver of convergence, both before and after World War II. During the Tokugawa period, feudal domains had substantial autonomy and promoted their own proto-industrialization. In addition, however, the central government, i.e., the shogunate authorities, assigned public works projects, such as the building of embankments and castles, to wealthy feudal domains, which worked as a geographical redistribution mechanism akin to fiscal federalism. Such public works projects boosted

activity in construction and public services, generating additional local income. Moreover, coupled with this redistribution mechanism, which spread the wealth of more prosperous domains across Japan and contributed to widespread improvements in infrastructure, was the fact that the central government monopolized almost all profits from international trade and mining. This reduced the influence of natural factor endowments and of geographical closeness to ports open to international trade (Nagasaki for trade with China and the Dutch East India Company, Tsushima for trade with Korea). These factors played an important role in equalizing per capita income across regions. In addition, the Tokugawa government and local governments made village communities responsible for tax collection from agricultural landowners. Therefore, village communities had an incentive to maintain landowners' ability to pay taxes, helping to keep the number of people in extreme poverty relatively small (Sakane, 2011: 132–200). Taken together, these policies and institutional arrangements during the Tokugawa period help to explain the relatively low degree of regional inequality at the onset of Japan's modern economic development.

Following the Meiji Restoration, the government introduced compulsory education at the primary level, which contributed to the accumulation of human capital in rural areas. At the time, supporting industries such as public and private railways expanded in rural Japan (Minami, 1965). Both education and transportation contributed to convergence. These types of policies continued throughout the entire period considered in this volume and culminated in the 1970s, with the massive accumulation of public capital in rural Japan resulting from large capital transfers from wealthier to poorer regions reducing regional income gaps. Data on prefectural capital and prefectural saving–investment balances, which are available from 1955, show that, from the 1970s, there were substantial public capital transfers and/or private capital flows from richer to poorer regions. This, coupled with migration, meant that rural areas experienced a more rapid increase in capital–labor ratios even though saving rates were higher in wealthier urban prefectures. Moreover, while capital flows from richer to poorer regions were particularly active during the 1970s and 1980s—largely due to the establishment of new factories—relatively active public investment financed mainly by public capital transfers continues until today.

Finally, the fourth important engine of convergence was technology diffusion, particularly in the post-war period. Since 1955, TFP in poorer regions has substantially caught up with that in wealthier regions, with most of this catch-up in TFP taking place in the manufacturing sector. The reason likely is the diffusion of technology as a result of the relocation of factories to rural regions as well as active accumulation of public capital in such regions. Since 1980, the catch-up in TFP of lagging regions has decelerated. This slowdown in the diffusion of technology can be explained by the expansion of city-type technology- or capital-intensive industries such as communication and real estate and by the decline in the establishment of new factories in rural regions as Japanese firms started to expand production capacity abroad, first particularly in Southeast Asia and the United States, and more recently in China.

The analysis of regional inequality presented in this volume only represents a start and many issues remain unexamined. Issues that warrant further investigation or further refinement include the following: first, a more detailed analysis of institutional aspects such as the supply of public goods and infrastructure, public finances, the role of the banking sector, and pork-barrel politics; second, the need to further bridge the gap between our sector-level analysis and micro-data analyses; and third, the importance of spatial issues, in particular agglomeration effects, the location decision of firms, and the determinants of the decision to migrate. We hope that the analysis presented here and the publication of our data (see Appendix 2) will spark future studies on these and other issues.

Appendix 1

Agricultural Production, Proto-Industrialization and Urbanization, 1600-1874[1]

A1.1 Introduction

Recent years have seen a growing interest by economic historians in the estimation of national output over the very long run. This interest to a large extent has been stimulated by the work of the late Angus Maddison on economic growth and development, including his estimates of long-run economic growth for various countries around the world.[2] His work has been continued by researchers from around the world in the form of the Maddison Project, and the first revised estimates of GDP growth before the pre-modern period were published in 2013.[3] For Japan, the revised estimates rely on the work of Bassino et al. (2011) providing GDP estimates going all the way back to the 8th century. These estimates were obtained by adding estimates of non-agricultural output based on the rate of urbanization to estimates of agricultural output.

Output estimates for pre-modern Japan to date have mainly focused on the agricultural sector. Among the first such estimates are those by Nakamura (1968), who estimated agricultural output for Japan as a whole from the Tokugawa period until the start of the Meiji period in order to examine economic conditions at the time of the Meiji

[1] This chapter greatly benefited from the input and advice of Professor Osamu Saito. Part of the work presented here, especially the estimation method of non-agricultural output, is taken from a discussion paper presented by Osamu Saito and Masanori Takashima at the conference on "Accounting for the Great Divergence," The University of Warwick in Venice, May 22-24, 2014 (Saito and Takashima, 2014).

[2] Maddison (2001; 2003).

[3] Bolt and van Zanden (2013).

Restoration. Relying on Nakamura's estimates for agricultural output, Miyamoto (2004) added arable land area and population estimates for a quantitative analysis of economic development during the Tokugawa period. Aggregate agricultural output in these studies is estimated from the supply side and measured in terms of *kokudaka*—the unit used for measuring yields in pre-modern Japan. However, these studies did not attempt to conduct any specific analyses of non-agricultural output such as the output of rural industries, which expanded markedly during the Tokugawa period.

Against this background, the purpose of this appendix is to present regional output estimates of agricultural production as well as estimates of secondary and tertiary sector output from the Tokugawa period until the start of the Meiji period. The appendix further provides an overview of the estimation approach we employed and presents an analysis of trends in sectoral output based on the estimates obtained.

The remainder of the appendix is organized as follows. The next section outlines the basic estimation approach. Section A1.3 then explains the estimation approach for regional output for the primary sector, while Section A1.4 does the same for the secondary and tertiary sectors. Next, Section A1.5 presents the total output estimates for the Tokugawa period and discusses the results. Finally, Section A1.6 summarizes the results and discusses issues for future research.

A1.2 Outline of the estimation approach

This section provides an outline of the approach we employ for estimating regional GDP from 1600 to 1874, explaining, among other things, the benchmark years, the regional division, and the industry classification we use.

Benchmark years

Regional GDP for the Tokugawa period is estimated for the following benchmark years: 1600, 1650, 1700, 1720, 1730, 1750, 1800, 1850, and 1874.

Regional division

While Japan is currently divided into 47 prefectures, the geographical division during the Tokugawa and early Meiji periods was very different. Tokugawa Japan consisted of around 70 *kuni* (old provinces). In the early Meiji period, following the abolition of feudal domains and the establishment of prefectures in 1871, Japan consisted of three *fu* (metropolitan prefectures) and 306 *ken* (prefectures), which in 1874, the last benchmark year of our estimates, were merged into three *fu* and 61 *ken*. Therefore, we have two different sets of regional divisions for our benchmark years: the *kuni* during the Tokugawa period and the prefectures in 1874 during the Meiji period.

For some regions the boundaries of the *kuni* and the prefecture remained almost unchanged, such as Omi province/Shiga prefecture and Tosa province/Kochi prefecture. However, for most regions the boundaries changed during the transition from *kuni*

to prefectures, although the extent of these changes differs. This means that for our estimation we need to make adjustments to take these boundary changes into account. Ideally, we would reorganize the available data into either the Tokugawa period *kuni* or the Meiji period prefectures. Unfortunately, however, the information available is insufficiently detailed to make this possible. Therefore, instead of using *kuni*- and prefecture-level data, we divide Japan into 14 regions that share distinct geographic and economic characteristics.[4]

Further, because Ezochi and Ryukyu (present-day Hokkaido and Okinawa prefectures) were not directly under the control of the Tokugawa shogunate and very little statistical data are available for these two regions, they are excluded from the estimation for the Tokugawa period and included only in 1874. The correspondence between *kuni*, prefectures, and regions in Japan's regional division in Tokugawa and early Meiji Japan is shown in Table A1.1.

Population data by region

The population data for 1874 are those estimated for this volume (see Appendix 2 for details). Apart from that, population data are mainly taken from Kito (1996).[5] However, because Kito's population estimates from 1600 to 1700 appear to be too low, Saito's (2002a) estimate for 1600 is used instead and figures for 1650 and 1700 are linearly interpolated using the population growth rate. Because of these adjustments, we refrain from estimating regional output for this period.

Unit of output and industry classification

The output unit we use for our estimates is *koku*, the unit of measurement employed by the feudal government during the Tokugawa period in the *kokudaka* system used to determine the value of land for taxation purposes. One *koku* is equivalent to the amount of unpolished rice necessary to sustain a person for a year (ca. 180 liters) and *kokudaka* measures the annual yield value of land.[6] Although originally a unit for rice, *koku* also came to be used as a measure for the value of agricultural output other than rice as well as marine and forest products, so that output in agriculture, forestry,

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[4] Details on boundary changes as a result of the transition from *kuni* to prefectures were taken from the *Kyobu Seihyo* [*Statistics on Munitions Research in 1875*] compiled by the Rikugun Sanbokyoku [Department of the Army General Staff] in 1875, from the *Dainihon Fuken Bunkatsuzu* [*Map of the Prefectural Division of the Japanese Empire*] compiled by the Naimusho Chirikyoku [Geography Bureau at the Ministry of Home Affairs] in 1881, and from the diagrams in Fujiwara (1964).

[5] Kito provides regional population estimates for 1600, 1721, 1750, 1756, 1789, 1792, 1804, 1822, 1828, 1834, 1840, 1846, and 1872. We used these population data and made adjustments for our benchmark years through linear interpolation.

Table A1.1 Regional division in Tokugawa and early Meiji Japan

	Region		Tokugawa period (*kuni*: old provinces)	Early Meiji (*fuken*: prefectures in 1874)	Current prefectures
1	East Japan	East Tohoku	Mutsu (Rikuo, Rikuchu, Rikuzen, Iwashiro, Iwaki)	Aomori, Iwate, Miyagi, Mizusawa, Fukushima, Iwamae, Wakamatsu	Aomori, Iwate, Miyagi, Fukushima
2		West Tohoku	Dewa (Uzen, Ugo)	Akita, Yamagata, Sakata, Okitama	Akita, Yamagata
3		North Kanto	Hitachi, Kozuke, Shimotsuke	Ibaraki, Tochigi, Niihari (partial), Kumagaya (partial)	Ibaraki, Tochigi, Gunma
4		South Kanto	Musashi, Sagami, Kazusa, Shimosa, Awa	Tokyo, Saitama, Chiba, Niihari (partial), Kumagaya (partial), Kanagawa, Ashigara	Tokyo, Saitama, Chiba, Kanagawa
5		Niigata/ Hokuriku	Sado, Echigo, Etchu, Noto, Kaga, Echizen, Wakasa	Niigata, Aikawa, Niikawa, Ishikawa, Tsuruga	Niigata, Toyama, Ishikawa, Fukui
6		Tosan	Kai, Shinano, Hida	Yamanashi, Nagano, Chikuma, Gifu (partial)	Yamanashi, Nagano, Gifu (partial)
7		Tokai	Izu, Suruga, Totomi, Mikawa, Owari, Mino	Hamamatsu, Shizuoka, Aichi, Gifu (partial)	Shizuoka, Aichi, Gifu (partial)
8	West Japan	Kinai	Yamashiro, Yamato, Izumi, Kawachi, Settsu	Kyoto, Osaka, Nara, Hyogo, Sakai	Kyoto (partial), Osaka, Nara, Hyogo (partial)
9		Around Kinai	Omi, Iga, Ise, Shima, Kii, Harima, Awaji, Tanba, Tango, Tajima	Shiga, Mie, Watarai, Shikama, Toyooka, Wakayama, Myodo (partial)	Kyoto (partial), Shiga, Mie, Wakayama, Hyogo (partial)
10		Sanin	Inaba, Hoki, Izumo, Iwami, Oki	Tottori, Shimane, Hamada	Tottori, Shimane
11		Sanyo	Mimasaka, Bizen, Bitchu, Bingo, Aki, Suo, Nagato	Hojo, Okayama, Oda, Hiroshima, Yamaguchi	Okayama, Hiroshima, Yamaguchi
12		Shikoku	Awa, Sanuki, Iyo, Tosa	Myodo (partial), Ehime, Kochi	Kagawa, Tokushima, Ehime, Kochi
13		North Kyushu	Chikuzen, Chikugo, Hizen, Iki, Tsushima, Buzen, Bungo	Fukuoka, Mizuma, Kokura, Saga, Nagasaki, Oita	Fukuoka, Saga, Nagasaki, Oita
14		South Kyushu	Higo, Hyuga, Osumi, Satsuma	Shirakawa, Miyazaki, Kagoshima	Kumamoto, Miyazaki, Kagoshima

Note: Excluding Ezochi and Ryukyu (present-day Hokkaido and Okinawa prefectures).
Sources: Saito (1983), Kito (1996).

Table A1.2 Population by region, 1600–1874 (in 1,000 persons)

	Region	1600	1650	1700	1720	1730	1750	1800	1850	1874
1	East Tohoku	—	—	—	2,333	2,307	2,203	1,912	1,993	2,419
2	West Tohoku	—	—	—	1,043	1,041	1,016	1,030	1,117	1,263
3	North Kanto	—	—	—	2,190	2,189	2,143	1,691	1,621	1,820
4	South Kanto	—	—	—	3,902	3,927	3,914	3,508	3,737	3,782
5	Niigata/Hokuriku	—	—	—	2,593	2,608	2,593	2,739	3,093	3,457
6	Tosan	—	—	—	1,251	1,269	1,284	1,356	1,435	1,471
7	Tokai	—	—	—	2,623	2,639	2,633	2,761	2,903	2,799
8	Kinai	—	—	—	2,696	2,658	2,567	2,446	2,366	2,184
9	Around Kinai	—	—	—	3,683	3,658	3,549	3,498	3,594	3,562
10	Sanin	—	—	—	837	857	887	1,006	1,052	1,029
11	Sanyo	—	—	—	2,407	2,432	2,445	2,661	2,935	3,042
12	Shikoku	—	—	—	1,822	1,850	1,875	2,065	2,345	2,456
13	North Kyushu	—	—	—	2,364	2,387	2,393	2,411	2,606	2,996
14	South Kyushu	—	—	—	1,294	1,334	1,406	1,498	1,683	2,236
	Total	17,000	21,846	28,074	31,037	31,156	30,908	30,582	32,481	34,516

Notes and sources: The total population for 1600 is taken from Saito (2002a). The data for 1750 are from Kito (1996). We adjusted the figure for the Tokai region for 1750 in Kito's estimates, because it was implausibly high when compared with earlier and later benchmark years. The data for 1874 are estimates for this volume (see Appendix 2 for details). Data for other years are obtained through linear interpolation based on the population estimates by Kito (1996).

and fishery during the Tokugawa period is gauged in terms of *kokudaka*. In this appendix, output in the forestry and fishery sectors is included in the *kokudaka* data.

We estimate regional output separately for the primary sector, the secondary sector, and the tertiary sector.[7] Ideally, we would like to estimate output for the different industries within each sector, but output data for the Tokugawa period are extremely limited, so that we restricted our estimation to the above three sectors.

What is more, data for the Tokugawa period are available only for the primary sector, and what data are available need to be treated with caution: as will be discussed in

[6] For 1874, output data in the statistical sources are recorded in yen. We estimated the *koku* values by dividing the yen values by 5.54 yen—the national average value of rice output per *koku* (Ohkawa et al., 1967)—for that year. As will be explained later, the output data for the primary sector for 1874 are those compiled for this volume. See Appendix 2 for further details on the construction of the primary sector output estimates.

[7] The three sectors consist of the following industries: primary sector—agriculture, forestry, and fishery; secondary sector—mining, manufacturing, and construction; tertiary sector—domestic trade, services, transport, communication, and utilities.

more detail later, previous studies suggest that there is a strong possibility that such data are underestimated. Meanwhile, for the other two sectors, no original data are available, so that we estimate output based on a regression model using prefectural time series data for the Meiji period (specifically, for the years 1874, 1890, and 1909).

A1.3 Estimates of regional output in the primary sector

This section explains the basic sources and approach used for estimating regional output in the primary sector. As mentioned, output data for the Tokugawa period are available only in terms of *kokudaka*, and we use these data for the estimation of output in agriculture, forestry, and fishery.

In his pioneering study on the Tokugawa economy, Nakamura (1968) suggests that the earliest relatively reliable output data for Tokugawa Japan probably are those from a survey conducted in 1645. Arguing that, unlike in earlier or later surveys during the Tokugawa period, the shogunate and *daimyo* managed to grasp agricultural output quite accurately in this survey, he regards the survey as reflecting actual production. Similarly, he regards the agricultural output data by the new Meiji government as providing an accurate reflection of actual production. He therefore uses the data for 1645 and data for the early Meiji period as benchmarks to estimate "actual *kokudaka*" or more realistic values of *kokudaka* for the other benchmark years. However, most scholars today believe that the discrepancy between the shogunate's or government's *kokudaka* figures and actual agricultural output was even greater than assumed by Nakamura. The purpose of this section therefore is to revise the estimates by Nakamura and provide new *kokudaka* estimates from the start of the Tokugawa period to the early Meiji period by linking different data series based on surveys by the Tokugawa shogunate and statistical data by the Meiji government for the Tokugawa and Meiji periods. Before presenting the revision of Nakamura's estimates, let us first explain his estimation procedure.

Specifically, for 1645, Nakamura used the survey carried out by the Tokugawa shogunate in that year. On the other hand, for 1867, he used the average values of the agricultural output data for 1877–1879 in the *Nosan Hyo* [*Agricultural Statistical Tables*] compiled by the Ministry of Agriculture and Commerce. Using these data for 1645 and 1867 as benchmarks, Nakamura then calculated the *kokudaka* for other benchmark years in the Tokugawa period for which no reliable data are available. These benchmark years are 1600, 1700, and 1830. Specifically, he estimated output for the remaining benchmark years using information on the number of engineering projects for the development of arable land (such as land reclamation projects) and on the increase in *kokudaka* from the Shoho period (1645–48) to 1867 (just before the start of the Meiji period) in the *Meiji Izen Nihon Dobokushi* [*History of Civil Engineering Works in Pre-Meiji Japan*] (referred to as *History of Civil Engineering Works* hereafter) compiled by the Doboku Gakkai (1936). Assuming that agricultural output increased by the same amount for each engineering project, Nakamura divided the total increase in *kokudaka* between 1645 and 1867 of 23,650,000 *koku* by the 1,467 projects recorded for this period,

so that each project is estimated to have increased output by 16,124 *koku*. He then estimated the increase in *kokudaka* in each period (i.e., 1600–1645, 1645–1700, 1700–1830, and 1830–1867) by multiplying the number of engineering projects during that period by 16,124 *koku* (i.e., the estimated increase in *koku* per engineering project). Finally, by adding this amount to the *kokudaka* for 1645 (or subtracting it in the case of 1600), he calculated the *kokudaka* for each benchmark year.

These estimates by Nakamura have subsequently been used by a number of scholars, including Miyamoto (2004) and Maddison (2001). However, these *kokudaka* estimates using the number of engineering projects are calculated based on the number of projects and output for Japan as a whole. Moreover, the number of projects in the *History of Civil Engineering Works*, which Nakamura employs, is aggregated on the basis of the current division into prefectures. Since the purpose here is to estimate primary sector output by region, this means that we need to count the number of projects on a county basis, aggregate them for each *kuni*, and then further aggregate them for the 14 regions.[8]

Therefore, for our estimation, we modify Nakamura's approach by aggregating the number of engineering projects in the *History of Civil Engineering Works* to the 14 regions and use these data to obtain the *kokudaka* for each of the 14 regions. Following Nakamura (1968), we assume that the only reliable data for the Tokugawa period are the survey data for 1645 and use these data for the estimation of output data for the other benchmark years during the Tokugawa period. On the other hand, Nakamura's approach of using the average values for 1877–1879 to represent output in 1867 seems rather problematic. Japan's economy developed very rapidly at the start of the Meiji period, so that such a 10-year gap is prone to producing considerable distortions. Fortunately, a number of alternative sources are available, and we use the data on agricultural, marine, and forestry output for 1874 from the *Meiji 7-nen Fuken Bussan Hyo* [*Tables of Prefectural Products, Meiji 7*] compiled by the Naimusho Kangyoryo [Agency for the Promotion of Industry of the Ministry of Home Affairs] in 1875 and aggregated by Furushima (1961) for output at the start of the Meiji period. Thus, we use data for 1645 and 1874 as our benchmarks and use these to calculate the *kokudaka* for the other benchmark years in the Tokugawa period for which no reliable data are available. Specifically, we calculate the increase in *kokudaka* per engineering project in each of the 14 regions and use this to estimate new *kokudaka* series for the period 1600 to 1874.

When counting the number of engineering projects for the development of arable land, we rely not only on the *History of Civil Engineering Works*, but also use information on such projects from the *Kyuhan Jidai no Kochi Kakucho Kairyo Jigyo ni Kansuru*

[8] The *History of Civil Engineering Works* provides annual tables summarizing all engineering projects. In practice, however, these annual tables contain errors and omissions, so that we corrected the calculation of the number of projects based on the description of each project in the text of the *History of Civil Engineering Works*.

Table A1.3 Engineering projects for new arable land development, 1598–1874

	East Tohoku	West Tohoku	North Kanto	South Kanto	Niigata /Hokuriku	Tosan	Tokai	Kinai	Around Kinai	Sanin	Sanyo	Shikoku	North Kyushu	South Kyushu	Total
1598 -1645	15	10	9	36	8	17	28	12	9	2	90	26	25	31	318
1645 -1697	49	12	13	28	36	19	41	12	27	14	256	40	41	46	634
1697 -1830	71	23	34	51	46	17	39	59	76	54	203	61	77	198	1,009
1830 -1874	21	48	40	15	31	16	19	16	55	36	139	42	95	187	760

Notes and sources: Norinsho Nomukyoku (1927) and Doboku Gakkai (1936). These sources do not provide information on land development in the Meiji period. We therefore estimated the number of engineering projects in the early Meiji period (1868–1874) based on the average annual number of engineering projects in the late Tokugawa period (1831–1867) for each region.

Chosa [*Survey on Land Reclamation Works During the Period of Former Feudal Domains*] (referred to as *Survey on Land Reclamation Works* hereafter) by the Norinsho Nomukyoku [Ministry of Agriculture and Forestry] (1927). The reason is that although the former mainly relies on the latter, there are many passages in the *Survey on Land Reclamation Works* that are not referred to, and we think that we can to some extent improve on the coverage of reclamation projects by supplementing the information in the *History of Civil Engineering Works*.

We use the regional output data for 1645 and 1874 to estimate output in each of the 14 regions in the remaining benchmark years. Specifically, the procedure is as follows. We start by aggregating the number of engineering projects for the development of arable land for each of the 14 regions from 1598 to 1874 from the *History of Civil Engineering Works* and the *Survey on Land Reclamation Works*. The results for each subperiod are shown in Table A1.3. We then calculate the increase in *kokudaka* per engineering project from 1645 to 1874 in each region by dividing the increase in *kokudaka* in each region by the number of engineering projects in each region during the same period, use this to estimate the increase in *kokudaka* in each region and subperiod, and finally calculate the estimated *kokudaka* for each region and year. The calculation is presented in Table A1.4, where panel (a) shows the *kokudaka* values for the 14 regions based on official reports. As mentioned, the data for years other than 1645 and 1874 are unreliable and substantially underestimate true output. We therefore calculate the increase in *kokudaka* per engineering project by dividing the increase in output in each region between 1645 and 1874 in panel (a) by the number of engineering projects in that region (shown in Table A1.3). The results are presented in panel (b). Next, we multiply the increase in *kokudaka* per engineering project with the number of engineering projects in each of the subperiods (panel (c)). Finally, we sequentially add (or subtract in the case of 1598) these increases in *kokudaka* for each observation year and region to the values for 1645 to obtain our estimates of each region's *kokudaka* in each year.[9]

However, Nakamura (1968) argues that even when estimating *kokudaka* series

Table A1.4 Estimates of *kokudaka* (in 1,000 *koku*)

(a) Reported *kokudaka*

	East Tohoku	West Tohoku	North Kanto	South Kanto	Niigata/ Hokuriku	Tosan	Tokai	Kinai	Around Kinai	Sanin	Sanyo	Shikoku	North Kyushu	South Kyushu	Total
1598	1,673	318	1,400	1,679	1,938	674	1,877	1,414	2,593	493	1,265	774	1,494	920	18,514
1645	1,431	966	1,924	2,125	2,644	833	1,996	1,475	3,111	724	1,586	963	2,026	1,348	23,152
1697	1,922	1,126	2,177	2,480	3,008	913	2,210	1,555	3,183	802	1,859	1,078	2,137	1,360	25,811
1830	2,874	1,295	2,413	2,770	3,622	1,137	2,416	1,616	3,552	883	2,550	1,351	2,571	1,438	30,488
1874	3,208	1,685	3,087	4,987	4,533	2,248	4,170	3,615	6,294	1,177	4,685	3,194	3,774	2,312	48,969

(b) Increase in *kokudaka* per engineering project between 1645 and 1874

	East Tohoku	West Tohoku	North Kanto	South Kanto	Niigata/ Hokuriku	Tosan	Tokai	Kinai	Around Kinai	Sanin	Sanyo	Shikoku	North Kyushu	South Kyushu
1645–1874	13	9	13	30	17	27	22	25	20	4	5	16	8	2

(c) Increase in *kokudaka*

	East Tohoku	West Tohoku	North Kanto	South Kanto	Niigata/ Hokuriku	Tosan	Tokai	Kinai	Around Kinai	Sanin	Sanyo	Shikoku	North Kyushu	South Kyushu	Total
1598–1645	189	87	120	1,096	134	463	615	295	181	9	466	406	205	69	4,335
1645–1697	617	104	174	853	602	517	901	295	544	61	1,326	624	336	103	7,057
1697–1830	895	199	454	1,553	769	463	857	1,451	1,531	235	1,052	952	632	443	11,485
1830–1874	265	416	535	457	518	436	417	394	1,108	157	720	655	779	418	7,274

(d) Estimated *kokudaka*

	East Tohoku	West Tohoku	North Kanto	South Kanto	Niigata/ Hokuriku	Tosan	Tokai	Kinai	Around Kinai	Sanin	Sanyo	Shikoku	North Kyushu	South Kyushu	Total
1598	1,242	879	1,804	1,029	2,511	370	1,381	1,180	2,929	716	1,120	558	1,821	1,278	18,817
1645	1,431	966	1,924	2,125	2,644	833	1,996	1,475	3,111	724	1,586	963	2,026	1,348	23,152
1697	2,049	1,070	2,098	2,978	3,246	1,350	2,896	1,770	3,655	785	2,913	1,587	2,363	1,451	30,209
1830	2,943	1,269	2,552	4,530	4,015	1,813	3,753	3,222	5,186	1,020	3,964	2,539	2,994	1,893	41,694
1874	3,208	1,685	3,087	4,987	4,533	2,248	4,170	3,615	6,294	1,177	4,685	3,194	3,774	2,312	48,969

Notes and sources: The figures for reported *kokudaka* in panel (a) for 1598, 1645, 1697, and 1830 are taken from Nakamura (1968), while those for 1874 are from Furushima (1961). For a small number of *kuni* data are missing in Nakamura (1968) for some years (Kazusa in South Kanto for 1645, Iki in North Kyushu for 1598, and Tsushima in North Kyushu for 1598–1830). We estimated missing values through linear interpolation (Kazusa and Iki) or, in the case of Tsushima, based on Tsushima's output share in North Kyushu in 1874. Figures for 1874 are converted from yen into *koku* at a rate of 5.54 yen per *koku*. For the other panels, see text.

Table A1.5 Comparison of agricultural output estimates for the early Meiji period (in 1,000 *koku*)

	Region	(A) New estimates	(B) *Bussan Hyo*	A/B
1	East Tohoku	6,696	3,208	2.09
2	West Tohoku	3,640	1,685	2.16
3	North Kanto	4,364	3,087	1.41
4	South Kanto	6,414	4,987	1.29
5	Niigata/Hokuriku	7,557	4,533	1.67
6	Tosan	3,379	2,248	1.50
7	Tokai	5,539	4,170	1.33
8	Kinai	4,376	3,615	1.21
9	Around Kinai	8,904	6,294	1.41
10	Sanin	2,216	1,177	1.88
11	Sanyo	6,893	4,685	1.47
12	Shikoku	5,768	3,194	1.81
13	North Kyushu	6,078	3,774	1.61
14	South Kyushu	4,528	2,312	1.96
	Total	76,351	48,969	1.56

Notes and sources: See text.

using the number of engineering projects in the above manner, these estimates do not fully capture actual agricultural output during the Tokugawa period. Although he does not provide a clear basis for this assumption, he assumes that in practice the discrepancy was about 20–30% of agricultural output. As mentioned above, though, most scholars today believe that the discrepancy between the shogunate's *kokudaka* figures and actual agricultural output was even greater than assumed by Nakamura, so that we need to adjust our *kokudaka* series upward.

The approach we use for this upward revision is to take the *kokudaka* value for 1874 obtained here and the primary sector output estimate for the same year based on the procedure described in Appendix 2 and calculate the ratio of the latter to the former. The results are shown in Table A1.5, where the column labeled "(A) New estimates" shows the new primary sector output estimates for 1874 constructed for this volume based on the procedure described in Appendix 2, while the column labeled "(B) *Bussan Hyo*" shows the *kokudaka* value from Table A1.4(d). Finally, the column labeled "A/B" shows the difference between the two in terms of their ratio, which we

[9] Note that at this stage, following Nakamura, we calculate *kokudaka* for years for which historical records are available (e.g., 1598 instead of 1600). We adjust the data to obtain the values for the benchmark years in the next step below.

use to adjust the *kokudaka* series for the Tokugawa period upward. Since the new primary sector output estimates for 1874 for this volume in column (A) are the adjusted values of the *Bussan Hyo* data, while column (B) shows the unadjusted values from the *Bussan Hyo*, we are essentially calculating the discrepancy between the adjusted and unadjusted values for 1874 and then applying this ratio to the values for the Tokugawa period.

The column labeled "A/B" in the table shows that the new estimates are larger by a factor of 1.56 for Japan as a whole, ranging from 1.21 for Kinai to 2.16 for West Tohoku. We use the ratio for each region to adjust the regional *kokudaka* series for the Tokugawa period upward. In addition, while the series so far were estimated for years for which historical records are available, we adjust the series to obtain the values for the benchmark years through interpolation of the growth rate, as explained in Section A1.2. Moreover, since the *kokudaka* values include forestry and fisheries output, we refer to them as primary sector output.

Table A1.6 shows primary sector output for each region and benchmark year as well as output per capita using the population estimates shown in Table A1.2. The table indicates that *kokudaka* consistently increased in all regions (panel (a)). In particular more advanced regions such as South Kanto, Kinai, Around Kinai, and Sanyo as well as non-mountainous regions (such as Tokai and North Kyushu) registered high growth. On the other hand, growth in mountainous regions such as North Kanto, Tosan, and Sanin lagged behind. Next, panel (b) presents developments in *kokudaka* per capita. Because reliable population data for the period before 1720 are unavailable, we calculated *kokudaka* per capita only from that year onward. Looking at the figures, what particularly stands out is the large increase in East Tohoku in the period from 1730 to 1850. This likely is due the decline in the population (see Table A1.2) as a result of famines, which frequently plagued the region during this period. Excluding East and West Tohoku, we find that although there were considerable differences in *kokudaka* per capita in the middle of the Tokugawa period (1720), they decreased gradually through the latter half of the Tokugawa period. Specifically, with *kokudaka* per capita ranging from 0.88 *kokudaka* (Kinai) to 2.30 *kokudaka* (South Kyushu) in 1720, the difference between the regions with the lowest and highest *kokudaka* per capita was 1.42 *kokudaka*, but by the start of the Meiji period (1874), this difference had fallen to 0.80 *kokudaka*, with *kokudaka* per capita ranging from 1.70 *kokudaka* (South Kanto) to 2.50 *kokudaka* (Around Kinai).

The trend in per capita *kokudaka* for Japan as a whole implied by our estimates is depicted in Figure A1.1. For comparison, the figure also shows the trend in national *kokudaka* per capita based on the series compiled by Miyamoto (2004). We find that in both cases, national *kokudaka* per capita decreases in the first half of the Tokugawa period (17th to early 18th centuries), but then recovers from the middle of the 18th century onward. In Miyamoto's series, per capita *kokudaka* in 1600, at the start of the Tokugawa period, is the highest throughout the era, and exceeds that at the beginning of the Meiji period, which seems rather implausible. Moreover, the decrease in the first half of the 17th century is quite substantial and gives the impression that the first half of

Table A1.6 Estimated *kokudaka* (including forestry and fishery), 1600–1874

(a) Levels (in 1,000 *koku*)

	Region	1600	1650	1700	1720	1730	1750	1800	1850	1874
1	East Tohoku	2,608	3,093	4,311	4,553	4,679	4,942	5,661	6,389	6,696
2	West Tohoku	1,906	2,107	2,320	2,380	2,411	2,474	2,638	3,121	3,640
3	North Kanto	2,557	2,743	2,979	3,068	3,114	3,207	3,452	3,935	4,364
4	South Kanto	1,365	2,824	3,866	4,119	4,251	4,529	5,300	6,087	6,414
5	Niigata/Hokuriku	4,195	4,497	5,438	5,615	5,705	5,891	6,380	7,074	7,557
6	Tosan	575	1,311	2,042	2,135	2,183	2,282	2,549	3,006	3,379
7	Tokai	1,863	2,748	3,869	4,023	4,102	4,266	4,701	5,230	5,539
8	Kinai	1,442	1,817	2,172	2,377	2,487	2,723	3,407	4,110	4,376
9	Around Kinai	4,154	4,469	5,211	5,493	5,640	5,946	6,779	8,014	8,904
10	Sanin	1,348	1,374	1,487	1,547	1,577	1,641	1,810	2,050	2,216
11	Sanyo	1,673	2,477	4,316	4,521	4,628	4,848	5,442	6,295	6,893
12	Shikoku	1,031	1,826	2,897	3,110	3,222	3,458	4,124	5,091	5,768
13	North Kyushu	2,947	3,312	3,826	3,965	4,036	4,183	4,572	5,361	6,078
14	South Kyushu	2,510	2,659	2,859	2,976	3,036	3,160	3,493	4,063	4,528
	Total	30,173	37,256	47,592	49,882	51,073	53,550	60,308	69,826	76,351

Notes and sources: See text.

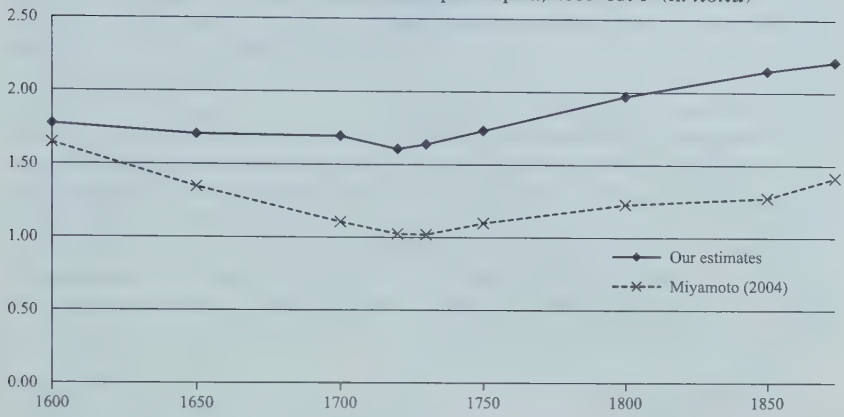
(b) Estimated *kokudaka* per capita (in *koku*)

	Region	1600	1650	1700	1720	1730	1750	1800	1850	1874
1	East Tohoku	—	—	—	1.95	2.03	2.24	2.96	3.21	2.77
2	West Tohoku	—	—	—	2.28	2.32	2.44	2.56	2.79	2.88
3	North Kanto	—	—	—	1.40	1.42	1.50	2.04	2.43	2.40
4	South Kanto	—	—	—	1.06	1.08	1.16	1.51	1.63	1.70
5	Niigata/Hokuriku	—	—	—	2.17	2.19	2.27	2.33	2.29	2.19
6	Tosan	—	—	—	1.71	1.72	1.78	1.88	2.09	2.30
7	Tokai	—	—	—	1.53	1.55	1.62	1.70	1.80	1.98
8	Kinai	—	—	—	0.88	0.94	1.06	1.39	1.74	2.00
9	Around Kinai	—	—	—	1.49	1.54	1.68	1.94	2.23	2.50
10	Sanin	—	—	—	1.85	1.84	1.85	1.80	1.95	2.15
11	Sanyo	—	—	—	1.88	1.90	1.98	2.05	2.14	2.27
12	Shikoku	—	—	—	1.71	1.74	1.84	2.00	2.17	2.35
13	North Kyushu	—	—	—	1.68	1.69	1.75	1.90	2.06	2.03
14	South Kyushu	—	—	—	2.30	2.28	2.25	2.33	2.41	2.03
	Total	1.77	1.71	1.70	1.61	1.64	1.73	1.97	2.15	2.21

Notes and sources: See text.

the Tokugawa period was a period of stagnation or even decline. In fact, Miyamoto (2004) himself recognizes that his agricultural output estimates for the first half of the Tokugawa period may underestimate the growth rate.

Figure A1.1 Trend in *kokudaka* per capita, 1600–1874 (in *koku*)



Note: The last observation in Miyamoto (2004) is for 1872 rather than 1874.
Sources: Miyamoto (2004) and Table A1.6(b).

In contrast, our estimate for per capita *kokudaka* in 1600 is higher than Miyamoto's, and the decline in the first half of the Tokugawa period is much more moderate. Again, per capita *kokudaka* recovers from around the early 18th century and continues to increase through the 19th century, rising above the value observed for the beginning of the Tokugawa period.

A1.4 Estimates of output in the secondary and tertiary sectors

Although constructing output estimates based on contemporary data for the primary sector is a challenge, such data are at least available. In contrast, no historical records that would allow a similar exercise for the other sectors are available. Therefore, instead of directly estimating output in the secondary and tertiary sectors from such sources, we take an indirect approach, employing regression analysis to obtain the determinants of the shares of the secondary and tertiary sectors in regional output based on time series data for the Meiji period. Using the results of this regression, we then estimate secondary and tertiary sector output backward for the Tokugawa period.

In his seminal work comparing pre-modern growth in Japan and the West, Smith (1988) described the economic growth of Tokugawa Japan as being characterized by rural-centered growth. That is, even before the rise of factory industry in the Meiji period, production in the non-agricultural sector developed in strides, supporting economic activities in the rural parts. For example, as highlighted by Smith (1988), although 82% of households within a particular district in Choshu, a domain in western Honshu, in the 1840s were farm households, 55% of the income of the total households

was derived from non-agricultural production. Moreover, taking a bird's-eye view of Choshu during the same decade, Nishikawa (2012) finds that the share of agriculture in total output was only 52.5%, while that of non-agricultural activities was 47.5%. These figures illustrate that even in the Tokugawa period non-primary sector activities already accounted for a substantial share of GDP.

A widespread approach for gauging output in non-agricultural activities in estimates of national accounts for pre-modern Western European countries is to use the urbanization rate as a proxy for the share of the non-agricultural sector (rural industry and commerce and services) in total output.[10] The underlying idea is that the development of cities is a key determinant of the growth of non-agricultural activities. Using Italian data, Malanima (2011), for example, showed that there was a strong positive correlation between the urbanization rate and the output share of the non-agricultural sector, using the following regression specification:

$$\left(\frac{Y_{na}}{Y}\right)\times 100=\alpha+\beta u+\varepsilon, \tag{A1.1}$$

where Y_{na} is non-agricultural output, Y is total output, and u is the urbanization rate. If it were relatively easy to distinguish between economic activities in cities and rural villages, as in the case of Italy's city-states, we could also apply this approach to Japan and estimate non-agricultural output based solely on the urbanization rate. However, the example of Choshu mentioned above suggests that manufacturing activities as well as commerce and services developed not only in the cities but also in smaller rural towns and villages with populations of less than, say, 5,000 inhabitants, that is, outside the urban centers.

Further, looking at developments in the urbanization rate during the Tokugawa period, we find that the degree of urbanization in Japan as a whole reached a peak in the mid-17th century and in fact declined during the second half of the Tokugawa period, albeit with some minor fluctuations. Therefore, if we assumed that the urbanization rate alone was a good proxy for the share of non-agricultural output in Tokugawa Japan, we would come to the conclusion that the non-agricultural output share declined during the second half of the Tokugawa period. However, as seen above, this would not be consistent with actual developments in the non-agricultural sector (rural industry and commerce and services). This means that in the case of Japan, using the urbanization rate alone as a proxy for secondary and tertiary sector output does not seem to be appropriate.

This is not to say that urbanization did not play a role in Japan's industrial development. However, the above considerations suggest that it is not the sole determinant, and that other factors must have played a role. In this context, Saito (1983), discussing Japan's proto-industrialization from the Tokugawa period to the beginning of the modern period, has argued that the start of rural industrialization is closely related to high

[10] See, e.g., Álvarez-Nogal and de la Escosura (2007), and Malanima (2011).

Table A1.7 Urbanization rates, 1600–1874 (in %)

	Region	1600	1650	1700	1720	1730	1750	1800	1850	1874
1	East Tohoku	—	—	—	6.6	7.3	8.1	9.7	9.3	6.5
2	West Tohoku	—	—	—	10.2	10.3	10.7	10.6	10.8	10.7
3	North Kanto	—	—	—	2.5	2.6	2.6	3.4	4.8	4.6
4	South Kanto	—	—	—	25.3	27.7	34.2	38.2	35.7	19.0
5	Niigata/Hokuriku	—	—	—	10.3	10.7	12.2	12.4	12.5	13.0
6	Tosan	—	—	—	3.1	3.8	3.8	3.6	3.5	3.3
7	Tokai	—	—	—	7.9	7.9	8.1	7.1	6.9	8.6
8	Kinai	—	—	—	34.7	35.8	38.5	36.8	34.8	30.2
9	Around Kinai	—	—	—	7.4	7.4	7.6	7.3	6.9	6.1
10	Sanin	—	—	—	8.2	8.2	8.3	7.8	7.9	6.6
11	Sanyo	—	—	—	7.1	7.0	6.8	6.0	5.1	7.2
12	Shikoku	—	—	—	6.1	6.0	5.8	5.5	5.1	7.6
13	North Kyushu	—	—	—	6.4	6.4	6.4	5.6	4.5	6.6
14	South Kyushu	—	—	—	6.9	6.9	7.5	8.9	7.8	7.4
	Total	6.1	13.5	12.0	11.6	12.1	13.4	13.3	12.4	10.3

Notes and sources: The figures are from Saito and Takashima (2014), who used population statistics or estimates from previous studies for cities for which these are available; for other cities, they took the population in 1872 from the *Nihon Chishi Teiyo* [*Outline of Japanese Regional Geography*] compiled by the Seiin Chishika [Geography Section of the Great Council of State] in 1877, and extrapolated backward using the urban population growth rates for each region calculated from the city population estimates in Saito (1984). Using these estimates, they define settlements with a population of more than 10,000 inhabitants as cities and aggregate them by region.

population growth and land pressure in the 17th century. He further argued that the driving forces of rural industrialization differ between eastern Japan, where increases in population density in areas of dry land farming unsuitable for grain production played a key role, and western Japan, where the interaction between agricultural development and the rise of markets was a more important factor. These arguments suggest that, in addition to urbanization, population density should be considered as an important determinant of rural industrial development. Thus, both population density and urbanization played a crucial role in rural industrialization, and the process driving rural development differed between eastern and western Japan.

Given these considerations, Saito and Takashima (2014) conduct a pooled regression using prefectural output data by industry for three points in time in the Meiji period (1874, 1890, and 1909) to examine the determinants of output in the secondary sector in and before the start of modern industrialization. Specifically, they estimate the following specification:

$$ln\left(\frac{Sshare}{1-Sshare}\right)=a_0+a_1\,lnD+a_2\,ln\left(\frac{U}{1-U}\right)+a_3m+a_4yr1+a_5yr2+\varepsilon. \quad \text{(A1.2)}$$

where *Sshare* is the share of the secondary sector in the sum of primary and secondary sector output, D is the population density in each prefecture (measured in terms of the number of persons per *cho* (=0.99 hectares)), and U is the urbanization rate of each prefecture. In this regression, population density is used as a proxy for the degree of rural industrial development, while the urbanization rate is regarded as a proxy for the degree of urban manufacturing. In addition, the regression contains a dummy for "modernized" prefectures, *m*, as well as two year dummies, *yr1* (for 1890) and *yr2* (for 1909). The rationale for and definition of these dummies are as follows. Although traditional industry (e.g., rural industry such as silk-reeling) played a large role in the industrialization of Meiji Japan, implying that all prefectures experienced modern industrialization to a greater or lesser extent, it seems likely that the process of modern industrialization during the Meiji period advanced at an uneven pace. Unless this uneven development is taken into account, the backward estimation of Tokugawa period output based on Meiji period data would produce skewed results. Saito and Takashima (2014) therefore construct a dummy for prefectures containing cities that were at the heart of modernization. Specifically, the dummy for "modernized" prefectures takes a value of one for Tokyo and Osaka in 1874 and 1890, and for Tokyo, Osaka, Aichi, and Fukuoka in 1909. Moreover, to take into account that modernization gradually spread through the rest of Japan during the Meiji period, they include year dummies for 1890 and 1909. Further, given that the differences in population density and the rate of urbanization across prefectures are quite large, they converted these variables into logarithmic and logit values.

The estimation of secondary and tertiary sector output presented in Saito and Takashima (2014) to a considerable extent relies on the data compiled for this volume. Specifically, they use the new estimates of gross prefectural product (GPP) and of prefectural populations compiled for this volume. Additional comments regarding the data they use are as follows. Because Hokkaido's and Okinawa's levels of development in the Meiji period were vastly different from those in the Tokugawa period, they exclude these two prefectures and focus on the remaining 45 prefectures in the estimation. Next, because urban population data for 1874 are not available, they estimate these figures through interpolation using the population growth rate for each city between 1873 and 1879.[11] For the urban population for 1890 they used the data from the *Nihon Teikoku Minseki Koko Hyo* [*Household and Population Statistics of Imperial Japan*] compiled by

[11] Specifically, they counted the population in each prefecture living in cities with 10,000 or more inhabitants, using the *Nihon Chishi Teiyo* in 1877 for 1873, and the *Kyobu Seihyo* in 1879 for 1875. However, some of the figures in the *Kyobu Seihyo* are rather dubious, so that they used estimates based on the figures for 1873 and the regional urban population growth rate up to 1873.

the Naimusho Shomukyoku [Administrative Bureau at the Ministry of Home Affairs] in 1891, while for 1909 they derived urban population data through linear interpolation using the values for 1908 and 1913 using the values recorded in various issues of the *Nihon Teikoku Jinko Seitai Tokei* [*Population Statistics of the Japanese Empire*] compiled by the Naikaku Tokeikyoku [Statistics Bureau of the Cabinet]. However, for cities whose boundaries changed and for the six major cities, they used the corrected values provided in Umemura et al. (1983). For the area of each prefecture used for the calculation of prefectural population densities, they used the figures recorded in the *Nihon Teikoku Jinko Seitai Tokei*.[12]

As in the case of the secondary sector, quantitative information on the tertiary sector during the Tokugawa period is essentially non-existent, and to date there have been no output estimates for this sector, so that the information available overall is extremely limited. Long-term estimates for European countries typically have used population growth rates and/or urbanization rates to estimate tertiary sector output.[13]

Saito and Takashima's (2014) estimation also takes population growth and urbanization into account. However, as mentioned, when considering economic growth in the Tokugawa period, it is necessary not only to take the growing role of markets and manufacturing in the urban parts into account, but also the development of rural industry in the process of proto-industrialization. The latter is likely to have gone hand-in-hand with the development of tertiary sector activities such as transportation, commerce, and services in rural parts of the country. Therefore, as in the case of the secondary sector, they took population density in addition to urbanization into account to reflect levels of rural development.

Based on the above considerations, they used the same specification as in equation (A1.2) for the tertiary sector:

$$ln\left(\frac{Tshare}{1-Tshare}\right)=a_0+a_1\,lnD+a_2\,ln\left(\frac{U}{1-U}\right)+a_3m+a_4yr1+a_5yr2+\varepsilon, \qquad \text{(A1.3)}$$

where *Tshare* is the share of tertiary industry in the sum of primary and tertiary sector output. The other variables are the same as in the estimation for the secondary sector.

The results of the two regressions for secondary and tertiary sector output shares are shown in Table A1.8. They show that all the variables are statistically significant. Both the secondary and tertiary sector output shares are positively correlated with the population density and urbanization rate. Meanwhile, the dummy variables (*m*, *yr1*, and *yr2*) pick up the impact of modern industrialization during the Meiji period and thus remove this from the remaining coefficient estimates, which will be used for the backward estimation of secondary and tertiary sector output in the Tokugawa period.

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[12] Prefectural areas in the *Nihon Teikoku Jinko Seitai Tokei* are recorded in km^2. Because all other estimations involving areas are conducted in *cho*, figures in km^2 were converted into *cho* (1 *cho* = 0.0099km^2).

[13] See, e.g., Deane and Cole (1967), Crafts (1985), and Broadberry et al. (2011).

Table A1.8 OLS regressions for the determinants of secondary and tertiary sector output shares

	Secondary	Tertiary
	(1)	(2)
Population density	0.4340***	0.4535***
	(5.37)	(7.74)
Urbanization rate	0.0980*	0.3305***
	(1.79)	(7.84)
Prefectural dummy	1.0521***	0.5790***
(Modernized = 1)	(5.21)	(3.72)
Year 1890 dummy	0.4738***	0.2873***
	(5.38)	(4.23)
Year 1909 dummy	0.8265***	0.3099***
	(8.69)	(4.23)
Constant	−1.7411***	−0.1730
	(−10.95)	(−1.41)
Adjusted R^2	0.7414	0.8258

Notes: The dependent variable in column (1) is the share of secondary sector output in the sum of primary and secondary sector output (logit transformed). The dependent variable in column (2) is the share of tertiary sector output in the sum of primary and tertiary sector output (logit transformed). t-values in parentheses. *** and * denote significance at the 1% and 10% level, respectively. The number of observations is 132.
Source: Saito and Takashima (2014).

A1.5 Backward estimation for the Tokugawa period

The next step consists of the backward estimation of GDP for the Tokugawa period. In doing so, we use the coefficient and intercept estimates for the secondary and tertiary sectors from the Meiji period estimation by Saito and Takashima (2014) described in the previous subsection, using the same methodology as employed in that paper.[14] Because the impact of the development of rural industry during the early Tokugawa period is likely to have been not very large, the coefficient for population density, which represents the degree of development of rural industry, is excluded from the estimation for the benchmark years 1600, 1650, and 1700.

Tokugawa period data necessary for this estimation are primary sector output, population density, and urbanization rates. For primary output, we used the *kokudaka* data estimated in Section A1.3, while the urbanization rates are those shown in Table A1.7. We calculated regional population densities by dividing Kito's (1996) population

Table A1.9 Population density, 1600–1874 (persons per *cho*)

	Region	1600	1650	1700	1720	1730	1750	1800	1850	1874
1	East Tohoku	—	—	—	0.51	0.50	0.48	0.42	0.43	0.53
2	West Tohoku	—	—	—	0.52	0.52	0.51	0.51	0.56	0.63
3	North Kanto	—	—	—	1.22	1.22	1.19	0.94	0.90	1.01
4	South Kanto	—	—	—	2.78	2.80	2.79	2.50	2.66	2.69
5	Niigata/Hokuriku	—	—	—	1.02	1.03	1.02	1.08	1.22	1.36
6	Tosan	—	—	—	0.57	0.58	0.58	0.62	0.65	0.67
7	Tokai	—	—	—	1.36	1.37	1.37	1.43	1.51	1.45
8	Kinai	—	—	—	3.89	3.84	3.70	3.53	3.41	3.15
9	Around Kinai	—	—	—	1.43	1.42	1.37	1.35	1.39	1.38
10	Sanin	—	—	—	0.82	0.83	0.86	0.98	1.03	1.00
11	Sanyo	—	—	—	1.16	1.17	1.18	1.28	1.42	1.47
12	Shikoku	—	—	—	0.99	1.01	1.02	1.12	1.28	1.34
13	North Kyushu	—	—	—	1.39	1.40	1.41	1.42	1.53	1.76
14	South Kyushu	—	—	—	0.53	0.54	0.57	0.61	0.68	0.91
	Total	0.59	0.76	0.97	1.08	1.08	1.07	1.06	1.13	1.20

Notes and sources: See text. 1 *cho* = 0.0099 km^2.

estimates for each *kuni* by the area of each *kuni* at the beginning of the Meiji period recorded in the first volume of the *Nihon Teikoku Tokei Nenkan* [*Statistical Yearbook of the Japanese Empire*].

Using the figures for primary sector output in Table A1.6(a) and the population density and urbanization rates, we then estimate secondary and tertiary sector output. The results are shown in Table A1.10, with panel (a) showing output estimates, panel (b) per capita output, and panel (c) the average annual growth rate in per capita output.

Starting with the output estimates, we find that output increased steadily in the economy overall as well as in each of the sectors throughout the period 1600–1874. On the other hand, output per capita remained more or less unchanged during the first half of the Tokugawa period, fluctuating between 2.5 and 2.8 *koku* per capita until 1750. It temporarily peaked at 2.73 *koku* per capita in 1650, but declined somewhat to 2.57 in 1720 before steadily rising from then on. Around 1750 it regained the peak level regis-

[14] However, the GDP estimates here are based on new estimates of primary sector output and therefore differ from the values obtained in Saito and Takashima (2014). The difference in primary sector output estimates arises from the fact that for 1874, Saito and Takashima (2014) use the agricultural output data from Nakamura (1968), which is the three-year average for 1877–1879 from the *Nosan Hyo*, while our estimates use data for 1874 from the *Bussan Hyo*.

Table A1.10 Output estimates for the Tokugawa period, 1600–1874

(a) Output (in 1,000 *koku*)

	1600	1650	1700	1720	1730	1750	1800	1850	1874
Japan	44,481	59,671	75,202	79,614	81,976	86,905	98,228	114,109	130,132
1 Primary	30,173	37,256	47,592	49,882	51,073	53,550	60,308	69,826	76,351
2 Secondary	4,044	5,445	6,866	7,556	7,789	8,233	9,307	11,002	14,248
3 Tertiary	10,263	16,970	20,745	22,176	23,115	25,123	28,614	33,281	39,534

(b) Per capita output (in *koku*)

	1600	1650	1700	1720	1730	1750	1800	1850	1874
Japan	2.62	2.73	2.68	2.57	2.63	2.81	3.21	3.51	3.77
1 Primary	1.77	1.71	1.70	1.61	1.64	1.73	1.97	2.15	2.21
2 Secondary	0.24	0.25	0.24	0.24	0.25	0.27	0.30	0.34	0.41
3 Tertiary	0.60	0.78	0.74	0.71	0.74	0.81	0.94	1.02	1.15

(c) Growth rate of per capita output (average annual rate, in %)

	1600–1650	1650–1700	1700–1720	1720–1730	1730–1750	1750–1800	1800–1850	1850–1874
Japan	0.09	−0.04	−0.22	0.25	0.33	0.27	0.18	0.29
1 Primary	−0.08	−0.01	−0.27	0.20	0.28	0.26	0.17	0.12
2 Secondary	0.09	−0.04	−0.02	0.27	0.32	0.27	0.21	0.83
3 Tertiary	0.51	−0.10	−0.17	0.38	0.46	0.28	0.18	0.47

Notes and sources: See text.

Table A1.11 Exports by type of commodity at the end of the Tokugawa period (in US$1,000)

Commodity	1865	1867
Raw silk thread	14,843	5,559
Silk egg cards	727	2,303
Tea	1,935	2,006
Copper	—	62
Japanese wax	51	123
Camphor	33	97
Coal	13	263
Dried fish	95	300
Other	794	1,371
Total	18,941	12,124

Source: Sugiyama (1989).

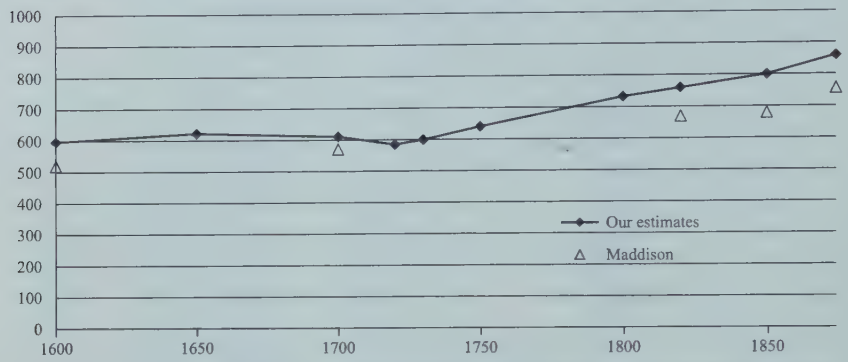
tered a century earlier and then continued to grow until the beginning of the Meiji period, reaching a level of 3.5 *koku* even before the fall of the Tokugawa shogunate.

Turning to sectoral per capita output, we find that primary sector output per capita declined during the 17th and early 18th century and started to increase again from 1730 onward. On the other hand, per capita output in the secondary and tertiary sectors increased more or less throughout the entire Tokugawa period. Growth in the two sectors was particularly strong during 1850–1874, with per capita output increasing at an average annual rate of 0.83% in the secondary sector and 0.47% in the tertiary sector. These rates are far higher than those observed during previous periods and contrast notably with that in the primary sector, where per capita output growth remained largely unchanged from previous periods.

The acceleration in secondary and tertiary sector per capita output growth likely reflects the opening of Japan to international trade at the end of the Tokugawa period and the resultant impact on the output of rural industry. Table A1.11 provides a breakdown of Japan's exports in 1865 and 1867. The table shows that raw silk thread and silk egg cards made up the large bulk, indicating that the silk industry had become the main pillar of Japanese exports. The silk reeling industry was a key protagonist of proto-industrialization in rural areas, and the rapid growth in secondary sector output likely to a considerable extent owes to the emergence of raw silk thread as a major export good.[15] The growth rate in per capita output in the tertiary sector during the same period likely is linked to this proto-industrialization in rural areas.

To gain a better sense of the estimates, Figure A1.2 shows the trend in GDP per capita for the economy as a whole from the start of the Tokugawa period to the early Meiji period and Maddison's GDP estimates for Japan in 1990 international Geary-Khamis dollars. The estimates by Maddison rely on an approach that is relatively similar to

Figure A1.2 Trend in GDP per capita, 1600–1874 (in 1990 international dollars)



Notes: Our estimates of GDP per capita in international dollars are as follows: $596 for 1600, $622 for 1650, $610 for 1700, $584 for 1720, $599 for 1730, $640 for 1750, $732 for 1800, $800 for 1850, and $860 for 1874. GDP per capita for 1874 includes Hokkaido and Okinawa.
Maddison's per capita GDP estimates are as follows: $520 for 1600, $570 for 1700, $669 for 1820, and $756 for 1874.
Sources: Table A1.10 and Maddison's original homepage (http://www.ggdc.net/maddison/oriindex.htm).

ours, in that he used time series data describing the growth process during the early modern period to estimate backward from 1820 to 1500 assuming that Japan's non-agricultural output during the Tokugawa period grew faster than agricultural output. This means that—despite some variation in growth rates across intervals—in Maddison's estimates Japan's economy registered moderate growth throughout the Tokugawa period.[16] In contrast, our results suggest that GDP per capita in 1600 was somewhat higher than estimated by Maddison, but then more or less stagnated over the following century, so that our and Maddison's estimates for 1700 are very similar. Subsequently, both sets of estimates show continuing growth in GDP per capita until the start of the

[15] The growth in Japanese silk-related exports reflects the development of silk mills in the United States as well as the spread of silkworm diseases in Europe (Sugiyama, 1989).

[16] Specifically, Maddison estimated GDP for Tokugawa Japan as follows. For agricultural output, he used Nakamura's (1968) estimates. On the other hand, for output in the non-agricultural sector, for which data series do not exist, he conjectures the rate of growth using a variety of contemporary records as well as preceding studies (most of which, however, provide only qualitative information) and adds this to the growth rate of Nakamura's estimates.

Meiji period, although our estimates are somewhat higher than Maddison's.

Looking at developments in more detail, our estimates suggest that in the first half of the Tokugawa period, Japan's GDP per capita remained essentially unchanged, increasing a little between 1600 and 1650 and then decreasing somewhat between 1650 and 1720, before starting to grow steadily until the end of the Tokugawa period and further into the Meiji period. This trend is in line with the widespread view expressed in earlier studies that Japan's economy had embarked on a sustained growth path in the 18th and 19th centuries.[17] Moreover, while Maddison's estimates suggest that growth was relatively sluggish between 1820 and 1850 but then suddenly accelerated in the last years of the Tokugawa period, our results suggest that growth was relatively evenly paced, with no major changes in economic performance between ca. 1720 and the end of the Tokugawa period.[18]

A1.6 Conclusion

The aim of this appendix was to produce new output estimates for Japan for the period 1600–1874. To this end, we started by estimating regional agricultural output from the Tokugawa period to the beginning of the Meiji period. We found that agricultural output tended to increase in all regions and that regional differences in *kokudaka* per capita decreased during the latter half of the Tokugawa period. For Japan as a whole, *kokudaka* per capita declined somewhat during the first half of the Tokugawa period and then recovered from around the early 18th century and continued to increase

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[17] See, e.g., Saito (1983), Miyamoto (2004).

[18] Given that a key interest of the present volume is developments in regional inequality over time, we also calculated the coefficient of variation (CV) in per capita GDP for the 14 regions. The values are: 0.151 for 1720, 0.143 for 1730, 0.135 for 1750, 0.137 for 1800, 0.138 for 1850, and 0.187 for 1874. If we include Ezochi (present-day Hokkaido) and Ryukyu (present-day Okinawa), the CV for 1874 is 0.233. And if we calculate the CV weighted by population, we obtain 0.154 for 1720, 0.144 for 1730, 0.134 for 1750, 0.134 for 1800, 0.134 for 1850, and 0.184 for 1874 (0.188 for 1874 if Ezochi and Ryukyu are included). However, it should be noted that the estimates for regional GDP on which these calculations are based are preliminary and based on ongoing research, so that they should be treated with a degree of caution. With that caveat in mind, while we cannot compare the size of the CVs here with that in Chapter 2 because of the difference in the number of geographical units, what we can look at is the trend in the CV over time. This suggests that regional inequality declined slightly from 1720 until 1750 and then remained essentially unchanged for the next 100 years, before increasing considerably between 1850 and 1874. Thus, it appears that the increase in regional inequality at the start of the Meiji period observed in Chapter 2 actually began before the observation period in that chapter, providing further evidence of an inverted Kuznets U curve at the start of Japan's industrialization process.

through the 19th century, rising above the value observed for the beginning of the Tokugawa period. Next, using new estimates for secondary and tertiary sector output, we estimated GDP per capita for the same period. We found that per capita GDP remained more or less unchanged during the first half of the Tokugawa period and then started to grow from the mid-18th century. This growth in per capita GDP was mainly driven by the development of the secondary and tertiary sectors.

Finally, some potential problems with our estimation results should be noted. One of these is that we were not able to take the circulation of goods into account. Throughout the Tokugawa period, Osaka was the center for trade in rice and handicraft industry goods produced in the *kuni* in its immediate and wider vicinity, thus forming an economic unit with them. Similarly, in the second half of the Tokugawa period, the capital, Edo, started to form similar economic relationships with surrounding areas, trading not only agricultural produce but also the products of rural industry such as silk with the rest of the Kanto area, forming the so-called "Edo economic sphere."[19] These economic "blocs" in which goods flowed freely with the help of urban wholesalers and that straddled major cities that acted as a centralized market and their surroundings, such as Osaka and its Kinai hinterland and Edo and its Kanto hinterland, or consisted of areas with a number of regional market centers, are bound to have played a role that cannot be ignored. What is more, the role of commodity flows is likely to have increased during the latter half of the Tokugawa period with the rise of rural industry and was further boosted by trade with the outside world following the opening up of Japan towards the end of the Tokugawa period. Another issue that arises in this context, given the extent of development of commerce during the Tokugawa period, is how merchant houses dealt with their income if they had their headquarters in Osaka or Kyoto, but had branches in Edo. The impact of these factors ideally should be taken into account when examining regional economic growth and development during the Tokugawa period.

The analysis presented in this appendix has mainly focused on outlining the approach employed for estimating national output during the Tokugawa period. A more detailed analysis of the estimates obtained, including a comparison with qualitative information in historical records and extant studies, as well as with the experience of other countries, can help us to gain a more detailed understanding of economic growth during the Tokugawa period.[20]

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[19] See, e.g., Miyamoto (2004).

[20] For example, although the period and regions covered in his analysis are limited, Odaka (1996) has attempted to gain a sense of developments over time in non-agricultural output for items such as industrial inputs as well as for the producer goods industry (charcoal, timber, copper, and iron), consumer goods industry (cotton textiles, soy sauce, and indigo), and marine transport.

Appendix 2

Construction of Prefectural Data for the Pre-World War II Period

A2.1 Introduction

As mentioned in Chapter 1, a major part of the research effort underlying this study has gone into the construction of original prefecture-level data for the pre-World War II period. The present appendix therefore provides a detailed description of how the prefecture-level estimates of sectoral output/value-added, labor input, and gross prefectural product (GPP) were obtained. The data will be publicly available (from September 2015) on the website of the Institute of the Economic Research, Hitotsubashi University: http://www.ier.hit-u.ac.jp/English/databases/index.html.

A2.2 Basic Estimation Strategy

This section outlines our basic strategy for the estimation.

A2.2.1 Geographical division

At present, Japan is divided into 47 prefectures.[1] For the purpose of our analysis, we also applied this geographical division to the pre-war period. As a result of the abolition of feudal domains and the establishment of prefectures in 1871, 3 *fu* (metropolitan prefectures) and 306 *ken* (prefectures) were established in the country as a whole, which were subsequently merged into 3 *fu* and 35 *ken*.[2] However, as a result of popular

[1] Strictly speaking, there are 47 administrative divisions, consisting of Tokyo-to, Hokkai-do, Osaka-fu, Kyoto-fu, and 43 other prefectures (*ken*).

movements to resurrect certain old prefectures, some were restored, and when eventually the prefectural system was officially proclaimed in 1890, Japan was organized into 3 *fu*, 43 *ken*, and 1 *do*, Hokkai-do, which at that time was under direct control of the central government. This means that for the period from 1890 onward, the administrative division of Japan remained almost unchanged: the only adjustments of prefectural territories we needed to make were for the three counties (*gun*) of Kita-Tama, Minami-Tama, and Nishi-Tama, control of which was transferred from Kanagawa prefecture to Tokyo-fu in 1893.

However, for 1874, we had to adjust our data to match the administrative divisions in 1874 to the 47 prefectures today. We did so by tracing changes in the prefectural "affiliation" of individual counties (*gun*) and adjusted prefectural data using information on the population of each *gun*, assuming that industrial production and industrial structure per capita were identical in all counties of a prefecture. We proceeded in a similar fashion with regard to the three counties of Tama-gun when these were transferred to Tokyo-fu in 1893 (see above).[3]

A2.2.2 Observation years

We estimated GPP by industry and for the total of all industries for the years 1874, 1890, 1909, 1925, 1935, and 1940. All values are on a calendar year basis. In addition, we also prepared annual estimates for agriculture for 1883-1940.

A2.2.3 Industry classification

A by-product of estimating GPP from the supply side is that it becomes possible to estimate prefectures' industrial structure. We estimated sectoral gross value added at market prices for each prefecture. For 1890 and later, we estimated gross value added of the following 16 industries:

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[2] However, the Ryukyu Kingdom was formally annexed by Japan only in 1872 and renamed Ryukyu Domain, before becoming Okinawa Prefecture in 1879. On the other hand, Hokkaido did not become a prefecture on equal terms with other prefectures until 1947, but instead was first governed by the Development Commission (Kaitaku-shi) established by the Meiji government (1869-1882) and then, following a brief division into three prefectures, by the Hokkaido Agency (1886-1947).

[3] The inaccuracies resulting from these adjustments are likely to be minor. In its estimates of agricultural production in Korea from 1910-1970, Hitotsubashi Daigaku Keizai Kenkyujo Tokei Gakari (1980), for example, takes account of changes in the territory of several *do* (districts) in Korea using both the area of land under cultivation and the population for adjustments, and finds that the two estimates are quite close.

Agriculture, forestry, and fisheries (*3*): (i) agriculture; (ii) forestry; (iii) fisheries.
Mining and manufacturing (*10*): (iv) mining; (v) food products; (vi) textiles; (vii) lumber and wood products; (viii) printing and publishing; (ix) chemicals; (x) stone, clay and glass products; (xi) metal and metal products; (xii) machinery; (xiii) miscellaneous.
Construction and tertiary industries (*3*): (xiv) domestic trade and service industries; (xv) construction; (xvi) transport, communication, and utilities.

For 1874, we could not split tertiary industries into (xiv) domestic trade and service industries and (xvi) transport, communication, and utilities. Therefore, for 1874 we have value added data for 15 industries only.

We also estimated the number of occupied (and non-occupied) persons by prefecture and type of occupation. For 1909 and later benchmark years, we estimated the number of persons for the following nine categories: (1) agriculture and forestry, (2) fisheries, (3) mining, (4) manufacturing and construction, (5) commerce, (6) transport and communication, (7) public administration (*komu*) and self-employed professionals, (8) domestic servants, etc., plus (9) non-occupied persons. It should be noted that the aggregate of (5) commerce, (7) public administration and self-employed professionals, and (8) domestic servants, etc., makes up the total of occupied persons in (xiv) domestic trade and services in the 16-industry-classification above.

For 1890, we estimated the number of occupied persons for the following seven categories: (1*) agriculture and forestry, (2*) fisheries, (3*) mining, manufacturing, and construction, (4*) commerce, (5*) transport and communication, (6*) other services (the sum of (7) public administration (*komu*) and self-employed professionals and (8) domestic servants, etc. above), and (7*) non-occupied persons. It should be noted that the utilities sector (electricity, water, and gas supply) is included in the manufacturing sector and not the transport and communication sector.

Finally, for 1874, we estimated the number of occupied persons for the following four categories: (1**) agriculture, forestry, and fisheries, (2**) mining, manufacturing, and construction, (3**) tertiary industries, and (4**) non-occupied persons.

A2.2.4 National-level sectoral gross value added control totals

Broadly speaking, the approach we adopted for estimating GPPs is an eclectic mix of relying on and adapting existing estimates for all of Japan, and of conducting our own estimates using original sources providing prefecture-level data. Specifically, for mining and manufacturing industry, forestry and fisheries, and construction we used the estimated output values by industry for the Japanese economy as a whole from the Long-Term Economic Statistics (LTES) as control totals and essentially conducted our estimation from the viewpoint of how these totals can be allocated to the different prefectures. Total output values for mining and manufacturing are taken from Shinohara (1972), those for forestry and fisheries from Umemura et al. (1966), and those for construction from Ohkawa, Takamatsu, and Yamamoto (1974).[4] However, whereas the

output data in the LTES often consist of net value added, which excludes fixed capital depreciation, we decided to estimate gross value added (i.e., including fixed capital depreciation) in line with conventions for GDP statistics. On the other hand, for agriculture, although we follow the methodology and sources of the LTES to some extent, we conducted our own estimates on the basis of original, prefecture-level statistical sources. Moreover, for tertiary industries, we conducted our estimates in such a way that the total value for Japan as a whole conformed with the values re-estimated by Settsu (2009). As a result, the total value for tertiary industries output for Japan overall also differs from Ohkawa, Takamatsu, and Yamamoto (1974) and others. It should further be noted that the LTES do not contain any GDP estimates for 1874. Therefore, we only use the LTES estimates for the manufacturing sector as control totals and construct new GDP estimates based on agricultural output data from the *Bussan Hyo* and new tertiary sector output estimates. While a detailed description is provided below, for the estimation of tertiary sector output for 1874 we essentially proceeded as follows. We calculated the average annual growth rate of real labor productivity in a particular service sector industry for the periods 1890–1909 and 1909–1925 and used this growth rate to extrapolate real labor productivity (output per worker) backward to 1874. We then multiplied the figures thus obtained by the number of persons employed in each industry to obtain real gross value added. Next, real gross value added was transformed into nominal values by calculating the difference between the rates of change of the deflators for the mining, manufacturing, and construction sector and the service sector for the periods 1890–1909 and 1909–1925, taking the average of the two periods, and adding this value to the rate of change of the mining, manufacturing, and construction deflator for the period 1874 to 1890. On the other hand, for the construction sector, we estimated real gross value added in 1874 making the strong assumption that the share of this sector in secondary sector real gross value added was the same as in 1890 and calculated nominal gross value added value using the deflator published in the LTES (Ohkawa et al., 1967).

Finally, it is worth noting that the supply-side estimates of the LTES are based on the United Nations 1968 System of National Accounts (1968 SNA), and are conducted

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[4] Whether Okinawa is included in the output totals in the LTES is somewhat unclear. In personal communication with the authors, Toshiyuki Mizoguchi, a member of the LTES project, indicated that Okinawa, which at the time of the estimation was occupied by the United States, was excluded from the estimation. However, in Shinohara (1972), Umemura et al. (1966), and Ohkawa, Takamatsu, and Yamamoto (1974) we were not able to find any clear statement one way or the other. In this study, we therefore assumed that Okinawa was included in the LTES estimates; but even if Okinawa is not included in the LTES estimates, this is unlikely to have a great impact on our estimation results, since Okinawa's share in national output is small (in terms of gross value added in local prices, the share in our estimates ranges from 0.4 to 0.8%).

on the basis of GDP (or net domestic product) at market prices. Given that we follow the approach of the LTES, this is consequently also the definition of gross domestic or prefectural product employed in our estimates.

A2.2.5 Adjustment for differences in prefectural price levels

Given that there is a tendency for the price level to be lower the poorer a country or region is, we need to take differences in the price level (purchasing power parity) into account, or else there is a risk that output in poorer prefectures will be underestimated. Consequently, we estimated not only nominal gross output and gross value added by industry using local prices, but also employing average prices for all of Japan. This is equivalent to comparing the output of each prefecture using the Laspeyres index with Japan as a whole as the base region.

Specifically, GPP in local prices for prefecture r in year t is calculated as

$$\sum_{i=1}^{I}\left(p_{i,r}(t)x_{i,r}(t)-\sum_{k=1}^{I}q_{k,r}(t)m_{k,i,r}(t)\right), \tag{A2.1}$$

where $x_{i,r}(t)$ denotes the output of good i in prefecture r in year t, $p_{i,r}(t)$ stands for the price received by producers of good i in prefecture r, $m_{k,i,r}(t)$ is the quantity of good k used as intermediate input for the production of good i, and $q_{k,r}(t)$ represents the price paid by producers in prefecture r for good k (for simplicity, prices of the same intermediate good are assumed to be the same even if purchased by different industries).

GPP expressed in national average prices is calculated as

$$\sum_{i=1}^{I}\left(p_{i}(t)x_{i,r}(t)-\sum_{k=1}^{I}q_{k}(t)m_{k,i,r}(t)\right), \tag{A2.2}$$

where $p_i(t)$ and $q_k(t)$ show the national average price of product i and of intermediate good k, respectively. $p_i(t)$ and $q_k(t)$ are defined as follows:[5]

$$p_i(t)=\frac{\sum_{r=1}^{R}p_{i,r}(t)x_{i,r}(t)}{\sum_{r=1}^{R}x_{i,r}(t)},\quad q_k(t)=\frac{\sum_{r=1}^{R}\sum_{i=1}^{I}q_{k,r}(t)m_{k,i,r}(t)}{\sum_{r=1}^{R}\sum_{i=1}^{I}m_{k,i,r}(t)}.$$

As can be easily confirmed, the total value of GPPs expressed in local prices and the total value of GPPs expressed in national average prices are the same by definition:

$$\sum_{r=1}^{R}\sum_{i=1}^{I}\left(p_{i,r}(t)x_{i,r}(t)-\sum_{k=1}^{I}q_{k,r}(t)m_{k,i,r}(t)\right)=\sum_{r=1}^{R}\sum_{i=1}^{I}\left(p_{i}(t)x_{i,r}(t)-\sum_{k=1}^{I}q_{k}(t)m_{k,i,r}(t)\right).$$

This identity also holds true for the gross value added of some goods and services

[5] Our data expressed in national average prices satisfy matrix consistency.

groups (e.g., the products of agriculture, forestry, and fisheries).

A2.2.6 Regional and intertemporal comparisons

In order to examine patterns and developments in GPPs, it would be very convenient if we could construct a table in which each column represents a particular year and each row a particular prefecture, with each cell showing the GPP for a particular year and prefecture, thus making possible a direct comparison both across prefectures and across years. The rows would then show developments in the output of specific prefectures, while the columns would make it possible to compare prefectures' output level in a particular year.

However, as explained in Fukao, Ma, and Yuan (2007), constructing a table that can simultaneously be read across prefectures and across years unfortunately is theoretically impossible. The principle reason is the change in the terms of trade (relative prices).

The following example demonstrates why this is the case. Assume that prefecture A produces only one agricultural product and prefecture B produces only semiconductors, and there are no intermediate inputs. Further assume that in 1990, the per capita GPP of the two prefectures in terms of the national average price was the same and that the population is fixed. Also assume that whereas output volume in prefecture A remains fixed from 1990 to 2000, output volume in prefecture B doubles during this period. Moreover, national average prices for agricultural products remained fixed, but those for semiconductors halve during this period.

If we tried to represent these developments in one table, we would run into the following problem. In terms of growth in GPP (the rows in the hypothetical table), this should be entered as showing that whereas the real GPP of prefecture A remained unchanged, the real GPP of prefecture B doubled. However, in terms of the cross-prefectural comparison of output levels (the columns in the hypothetical table), the per capita GPP in the two prefectures measured in terms of national average prices should be entered as identical in both 1990 and 2000. This means that although the real gross output of prefecture B doubled, it did not become wealthier than prefecture A because the price of its product (semiconductors) fell.

Time-series estimates such as those of the Penn World Table and Angus Maddison (e.g., Maddison 1995, 2003) place importance on information on economic growth (i.e., the rows in our example), where purchasing power parity is used only for a relatively recent single point in time to compare countries' relative income, while income levels for years are obtained through extrapolation using the growth rate of per capita real GDP. Using these kinds of tables for the comparison of income levels across countries (i.e., down the columns in our example) for years other than the benchmark year is therefore problematic.[6]

Because we are mainly interested in economic differences across prefectures, our estimates focus on making them comparable down the columns. That is to say, we devoted our main effort to constructing a table that allows us to examine for each year

in which prefecture Japan's GDP as a whole was produced, expressed in regional prices and in national average prices, based on information for the appropriate year. Nevertheless, for reference, we also constructed tables providing estimates of the real GPP for each prefecture, but we were not able to sufficiently prepare price and real output data, and for industries other than agriculture estimated the following simple equation:

$$\sum_{j=1}^{16}\left(\frac{GVAR_j(t)}{GVAN_j(t)}\sum_{i\in I_j}\left(p_i(t)x_{i,r}(t)-\sum_{k=1}^{I}q_k(t)m_{k,i,r}(t)\right)\right). \qquad \text{(A2.3)}$$

where j stands for the 16 industries and I_j represents the set of goods and services of industry j. $GVAR_j(t)$ is the real gross value added (in 1934–1936 prices) in Japan as a whole in industry j in year t estimated in the LTES, and $GVAN_j(t)$ is the nominal gross value added in Japan as a whole in industry j in year t estimated in the LTES. In other words, we used the estimate for Japan as a whole from the LTES as the implicit deflator for gross value added for each industry.

It should be noted that when estimating real output using equation (A2.3) and using this to calculate economic growth rates, there is a risk that if a prefecture becomes better off as a result of favorable developments in the terms of trade, i.e., changes in relative prices across prefectures for the goods and services of a particular industry, this may give the false impression of that prefecture having registered economic growth.

A2.3 Agriculture, forestry, and fisheries

The main aim of this section is to explain the methodology and sources used for the estimation of GPP in agriculture for the period 1874 to 1940. In addition to estimates in local prices, we also produced estimates in national average prices to adjust for interregional price differences, and estimates of real values expressed in 1935 prices to allow comparisons over time. Moreover, for forestry and fisheries, we allocated gross value added estimates for Japan as a whole taken from the LTES (Umemura et al., 1966) to prefectures based on the number of occupied persons. Details of this simple methodology are provided at the end of this section.

Our general strategy for the estimation of agricultural output by prefecture was to use, wherever possible, prefectural output volumes and local prices. For estimating agricultural output in 1874, we relied mostly on the *Fuken Bussan Hyo* [Tables of Prefectural Products] (*Bussan Hyo* for short hereafter) for the different prefectures in 1874. For the period 1883–1940, we relied on data by item and prefecture reported in the *Noshomu Tokei Hyo* [Statistical Yearbook of the Ministry of Agriculture and Com-

[6] That being said, in addition to the real GDP series for the analysis of growth over time, the Penn World Table also includes real GDP per capita series adjusted for changes in the terms of trade, which allow cross-section analyses.

merce] and the *Nihon Teikoku Tokei Nenkan* [Statistical Yearbook of the Japanese Empire].[7] However, for a number of items, we used the price information reported in the LTES (Umemura et al., 1966), while for several other items of relatively little importance, we simply allocated the estimated output for Japan as a whole in the LTES (Umemura et al., 1966) to prefectures using prefectural acreage data or population estimates.

The remainder of this section is organized into two subsections. The first subsection describes our estimation procedure for agricultural output for the benchmark years 1890, 1909, 1925, 1935, and 1940. We begin by presenting in detail the method employed for constructing prefectural series of gross output values for rice and five other important staple crops (barley, naked barley, wheat, soybeans, and *azuki* beans). Next, we describe the estimation procedures for generating prefectural gross output series for six other staples crops (millet, barnyard millet, foxtail millet, buckwheat, sweet potatoes, white potatoes), and for five industrial crops (cotton, hemp, indigo, tobacco, and rapeseed) for which prefectural acreage and output data are available. Further, we construct prefectural series of tea output and cocoons production on the basis of prefectural series of tea and mulberry plantations acreage and LTES estimates (Umemura et al., 1966) of output volume for Japan as a whole. In addition, we extrapolate prefectural output for other products from LTES series and prefectural population data. Finally, we estimate intermediate inputs and gross value added in local prices, in national average prices, and in real terms expressed in 1935 prices. The second subsection describes our estimation procedures for the benchmark year 1874.

A2.3.1 Estimation procedures for the benchmark years 1890, 1909, 1925, 1935 and 1940

a) Estimation of gross prefectural output of major staple food crops

For the six major staple crops (rice, barley, naked barley, wheat, soybeans, and *azuki* beans) we calculated annual series of gross output on the basis of prefectural output volumes and local unit prices. According to the LTES estimates, the total output value of these six items accounted for 72.7% of Japan's gross agricultural output in 1890, 60.7% in 1909, 56.8% in 1925, 60.5% in 1935, and 52.1% in 1940 (Table A2.1). Rice output series have been reconstructed very carefully by the authors of the LTES series on the basis of prefectural paddy field acreage and paddy output volumes, but the revision they introduced concerned exclusively the period prior to 1890. It is not surprising, therefore, to find that, for the period 1890–1940, the LTES figures for total acreage and output for Japan as a whole are identical to those reported in the *Noshomu Tokei Hyo*. The discrepancy between the LTES and the *Noshomu Tokei Hyo* for 1888 and 1889 is

[7] A detailed description of the *Fuken Bussan Hyo* and the *Noshomu Tokei Hyo* is provided in Section A2.4.

Table A2.1 Share of the six main staple crops in total Japanese gross agricultural output (in %)

	1890	1909	1925	1935	1940
Rice	58.8	48.4	47	50.7	39.7
Barley, naked barley, and wheat	10.6	9.8	7.9	8.4	10.7
Soybeans, *azuki* beans	3.3	2.6	2.0	1.4	1.7
Total	72.7	60.8	56.9	60.5	52.1

Note: Authors' calculation based on LTES output volumes and producer price series (Umemura et al., 1966).

only 2% and 1%, respectively. In order to achieve complete coverage for the period starting in 1883, we extrapolated rice output for prefectures for which information was missing in 1883–1887: output volumes for Nara, Kagawa, and Okinawa prefectures were extrapolated assuming the same trend as for Osaka, Tokushima, and Kagoshima prefectures, respectively. The same procedure was used for other items for which information for these prefectures was also missing.

LTES output volume series for barley, naked barley, wheat, soybeans, and *azuki* beans are identical to the figures reported in the *Noshomu Tokei Hyo* for the years 1888, 1892, and the period from 1894 onward (data for 1889–1891 and 1893 are missing; data for *azuki* beans are not reported before 1892, and some minor differences are observed in 1888 and 1892 for soybeans). All missing data in existing series were interpolated (including data for 1885–1887 and 1889–1891 in the case of soybeans, and 1885–1893 in the case of *azuki* beans). However, for the period before 1885, the authors of the LTES (Umemura et al., 1966) thought that the output volumes reported in the *Noshomu Tokei Hyo* were underestimated. They therefore extrapolated output volumes backward. LTES estimates are about 50% higher than the official data in the *Noshomu Tokei Hyo* for *azuki* beans and about 15% higher for barley, naked barley, wheat, and soybeans.[8]

It should be noted that it is possible that available output series for rice, barley, naked barley, wheat, and other grains for the early Meiji period do not include seed

[8] The reason why Umemura et al. (1966) thought that the output volumes reported in the *Noshomu Tokei Hyo* before 1885 were underestimated is that the rise in yields implied by acreage and output volume data reported in the *Noshomu Tokei Hyo* seems implausible; technical change did occur in paddy cultivation, but it is unlikely that this had a significant impact on other staple crops. However, the backward extrapolation procedure employed in the LTES also appears unsatisfactory, since it relies on output volumes without taking acreage and therefore yields into account. Moreover, both the output data reported in the *Noshomu Tokei Hyo* and the LTES output estimates are inconsistent with early Meiji consumption surveys (see Bassino, 2006b).

used for production in the following year. For instance, at present, it is not possible to say with certainty whether the output data in the *Noshomu Tokei Hyo* include seed, and whether the statistical treatment of seed differs by prefecture. However, even if, as a result of this, output of rice, the most important agricultural product, is underestimated, ignoring this is unlikely to give rise to large distortions, because the share accounted for by seed in total output is extremely small: the same can be said for pulses such as soybeans and *azuki* beans as well as some cereals such as foxtail millet and buckwheat. In the case of other grains, especially barley and wheat, the share of seed in total output is far greater than in the case of rice. However, with regard to these grains, a far more important reason for the underestimation of yields than the removal of seed from output volumes is the underreporting of output volumes. In any event, the underreporting of rice output is of some significance only before 1886.[9] Regarding the estimation of prefectural output from 1890 onward, we decided to use the statistics on prefectural output volumes from the *Noshomu Tokei Hyo* as they are.

The next task is to estimate local prices. We rely on annual averages of local wholesale prices reported in the *Nihon Teikoku Tokei Nenkan* and compare these series with LTES national averages of producer prices (Umemura et al., 1966).[10] The description of the LTES estimation procedures indicates that producer prices series were based on data recorded for the benchmark years 1888, 1899–1901, and 1909–1911. We were able to collect local price data for rice, barley, and soybeans covering most Japanese prefectures for the period 1887–1899, and covering more than half of the prefectures for the period 1910–1918. A relatively high degree of coverage is also obtained for the same years for naked barley, soybeans, and *azuki* beans.

Figures A2.1 and A2.2 provide a comparison of LTES producer prices and the unweighted averages of wholesale prices for rice and barley for prefectures for which almost continuous price series are available. The most extensive regional wholesale price data set available for the period 1875–1939 is based on information for 13 prefectural capitals: Tokyo, Yokohama (Kanagawa prefecture), Osaka, Kobe (Hyogo), Kyoto, Nagoya (Aichi), Hiroshima, Kochi, Fukuoka, Kanazawa (Ishikawa), Niigata, Sendai (Miyagi), and Otaru (Hokkaido) (labeled "Average 13" in the figures).

The two figures show that there are substantial deviations between the national

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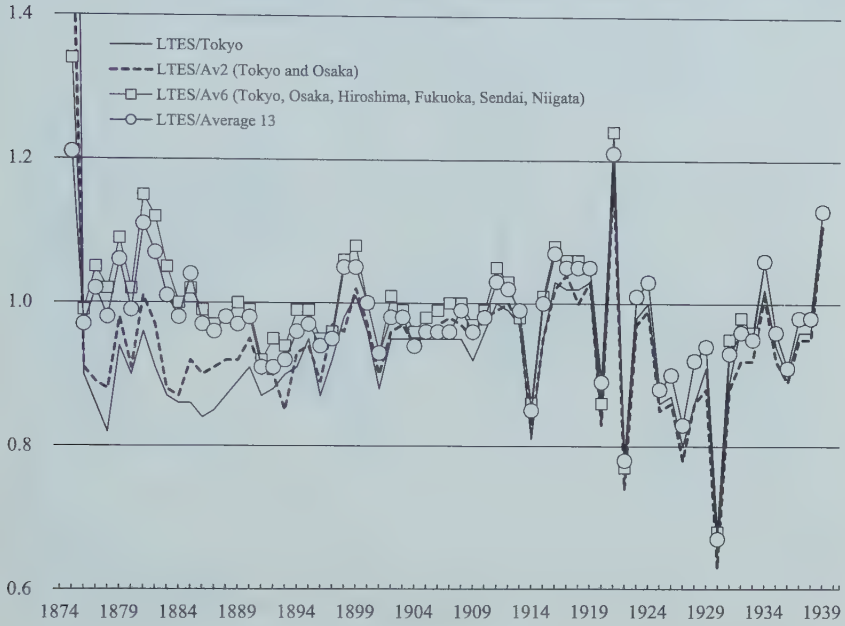
[9] This is further discussed in Section A2.3.2 dealing with the estimation of agricultural output for 1874.

[10] When looking at price data for agricultural products, it is necessary to consider differences in the processing stage of the product. The producer price for rice in Japan during the Meiji period generally is the price for polished rice (and not unhulled or unpolished rice), and the same can also be said for the price data in the LTES (Umemura et al., 1966). The regional price data in this study are wholesale data, and with regard to other grains and agricultural produce, too, the sources do not explicitly state whether prices are for processed goods, although, as with rice, this is likely to be the case.

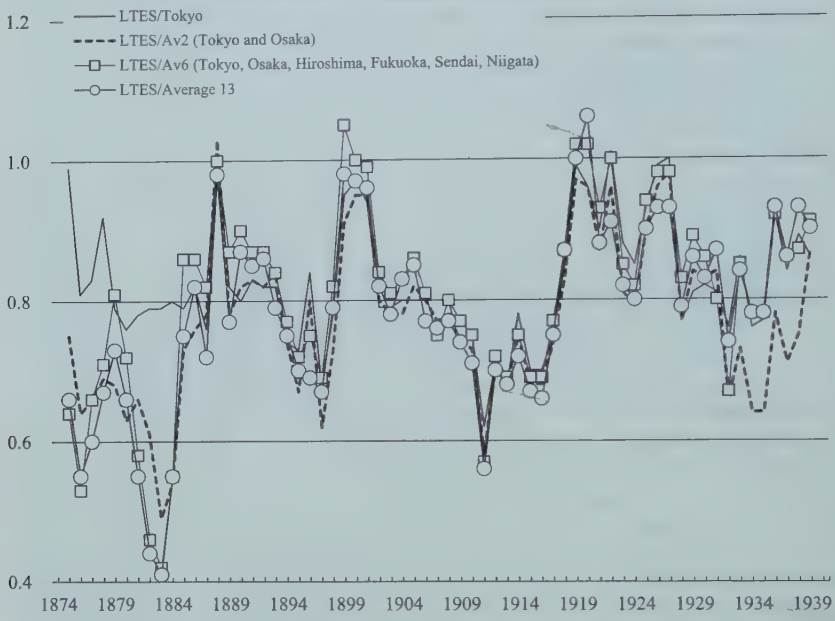
Figure A2.1 National average producer prices from the LTES (Umemura et al., 1966) relative to local wholesale prices: Rice



average producer prices reported in the LTES (Umemura et al., 1966) and the average wholesale prices for the 13 prefectures ("Average 13"). At present, we have no explanation for these deviations. The movements in the averages for the different regional aggregations resemble each other quite closely, suggesting that the wholesale price data are indeed reliable. Similar results were obtained for wheat, naked barley, and soybeans (in the case of soybeans, we can rely on price data covering the entire period from 1875–1939 for only six markets: Tokyo, Osaka, Hiroshima, Kumamoto, Sendai, and Niigata).

Based on this examination of prices, we decided to estimate producer prices by prefecture on the basis of local wholesale prices, adjusting these, and filling in missing data through extrapolation. For the adjustment, we assumed a wholesale margin equivalent to 10% of the wholesale price. When some oddities were observed, such as the relatively high price of soybeans in Tokyo during the 1920s or the high price of barley in Osaka in 1932–1938, we decided to amend these figures assuming that the trend was the same as in Osaka and Tokyo, respectively. Missing price data for *azuki* beans were extrapolated on the basis of the relative price of *azuki* beans and soybeans for available years (data covering the period 1887–1892 are available for all prefectures except Hokkaido and Okinawa). Data for 1940 that are missing in the *Nihon Teikoku Tokei Nenkan*

Figure A2.2 National average producer prices from the LTES (Umemura et al., 1966) relative to local wholesale prices: Barley



were extrapolated assuming the same variation as in the LTES price series.

b) Estimation of gross prefectural output of other staple crops and industrial crops

Prefectural acreage and output volume series are also available for six other staples (foxtail millet, barnyard millet, proso millet, buckwheat, sweet potatoes, and potatoes), and five industrial crops (cotton, hemp, indigo, tobacco, and rapeseed). According to LTES estimates (Umemura et al., 1966), these 11 crops accounted for 7.9% of agricultural gross output in 1890, 8.4% in 1909, 5.4% in 1925, 5.7% in 1935, and 7.8% in 1940 (see Table A2.2).

As in the case of barley, naked barley, and wheat, the upward trend in yields suggests that output volumes reported in the *Nihon Teikoku Tokei Nenkan* were grossly understated before the 1910s, particularly before 1890. For the same reason, as for barley, naked barley, and wheat, no attempt was made to reconstruct yields and therefore output at the prefectural level; missing output volume data for Nara, Kagawa, and Okinawa were extrapolated as already indicated above and other missing data interpolated. As it proved impossible to reconstruct local price series for these six staples and five industrial crops we relied on LTES estimates of national averages of unit price series.

Table A2.2 Share of secondary staple crops, industrial crops, fruits, vegetables, sericulture products, and other animal products in Japan's gross agricultural output (in %)

	1890	1909	1925	1935	1940
Foxtail millet	1.3	1.6	0.4	0.2	0.2
Barnyard millet	0.3	0.2	0.1	0.1	0.1
Proso millet	0.1	0.2	0.1	0.1	0.1
Buckwheat	0.1	0.1	0.0	0.0	0.0
Sweet potatoes	2.1	3.7	2.5	2.4	3.2
White potatoes	0.1	0.6	0.8	1.0	1.7
Cotton	1.2	0.0	0.0	0.0	0.0
Hemp	0.4	0.3	0.1	0.4	0.4
Tobacco	0.5	0.8	1.1	1.6	1.6
Indigo	0.8	0.2	0.1	0.0	0.0
Rapeseed	1.1	0.8	0.3	0.5	0.4
Sugarcane	0.5	0.8	0.2	0.3	0.2
Tea	0.9	1.0	0.8	0.7	1.1
Other industrial crops	1.5	1.8	1.7	1.9	2.0
Vegetables	4.7	7.2	6.4	7.0	8.5
Fruits	1.0	2.0	2.0	2.3	3.9
Green manure and forage crops	0.7	0.6	0.7	0.7	0.7
Straw goods	1.4	1.1	1.1	1.2	0.9
Cocoons	5.0	9.7	18.1	11.1	13.4
Other animal products	1.5	3.3	4.3	6.0	7.1

Source: See Table A2.1.

We constructed local prices by assuming the same magnitude of regional differentials as for a composite index calculated on the basis of the price of a basket of rice and barley, with a weight of 1 *koku* for each of these items.

c) *Estimation of gross prefectural output of silk and tea*

Prefectural silk and tea output was estimated by relying on LTES output volume estimates. LTES series of cocoon output volume appear much more plausible than the figures recorded in official sources, which imply that domestic demand was almost nil in early Meiji (that is, recorded output volume figures are only slightly higher than export volume figures).

During the entire period studied, silkworm cocoons are second only to rice in terms of gross output value of a single item. According to the LTES estimates, sericulture products accounted for 5.9% of gross agricultural output in 1890, 11.1% in 1909, 19.1% in 1925, and 13.9% in 1940. Cocoons accounted for more than 80–90% of total sericulture output, with silkworm eggs making up the rest.

To estimate prefecture-level output of cocoons, we took the LTES national output volumes measured in terms of weight and allocated these among prefectures on the

basis of prefectural series of acreage under mulberry plantation. Output volume of mulberry leaves is unavailable, but this is a minor inconvenience, since we are only concerned with value added. Mulberry leaves were used as input in sericulture production, as were silkworm eggs. Although silkworm eggs were traded nationally and internationally (exported in particular to Europe), it seems acceptable to consider that only a negligible share of prefectural output was not used as input in the same region (we do not have sufficient information on the regions of origin and destination of traded eggs to attempt an adjustment).

Tea output accounted for only around 1% of total agricultural output, with a very high degree of regional specialization, concentrating increasingly on Shizuoka prefecture as the main region of tea production in Japan. As in the case of silk, we use the LTES series of tea output volume and allocate a share to each prefecture on the basis of acreage under tea plantation for any given year. Regional unit price series of cocoons and tea are extrapolated from LTES producer prices series in the same way as for the six staples and six industrial crops listed above.

d) Estimation of gross prefectural output of other items

For all other items, we allocated national gross output series among prefectures by assuming the same per capita output across Japan. These other items include several staples of minor importance—grain sorghum (*morokoshi*), maize, oat, rye, peanuts, peas, broad beans, kidney beans, and cowpeas—as well as vegetables, fruits, and edible animal products of animal husbandry (meat, poultry, and eggs). As most of these items were essentially traded locally, per capita output can be regarded as a proxy of per capita food supply. Considering the relatively high degree of homogeneity in consumer preferences across the Japanese archipelago, it seems reasonable to presume similar levels of per capita output among Japanese prefectures, although this of course does not apply to some items; for example, the climate of northeast Japan and Hokkaido is not suited for the cultivation of citrus trees, while pork was mostly consumed in Kyushu and Okinawa. Moreover, there is evidence of a relatively high degree of regional specialization in industrial crops such as *konnyaku* roots, sesame, wax, and sugarcane. Nevertheless, given that most of these products accounted for only a very small percentage of total output, it seems safe to assume that, for all staples of minor importance, vegetable, fruits, as well as animal products other than cocoons, and industrial crops other than those mentioned in Section A2.3.2, output volumes per capita were at similar levels in the different prefectures in any given year.

However, with regard to sugarcane production, this poses a potential problem, because the bulk of the output originated from Okinawa; our estimates will therefore tend to understate value added in agriculture for this prefecture.

It should be noted that the rapid rise between 1890 and 1925 in the share of fruits, vegetables, and edible animal products in Japanese agricultural gross output value implied by LTES series is rather implausible. As can be seen in Table A2.2, the shares of these items jumped considerably: from 4.7 to 7.2% in the case of fruits, from 1.0 to 2.0% in the case of vegetables, and from 1.5 to 3.3% in the case of edible animal prod-

Table A2.3 Nominal output and nominal gross value added in agriculture for Japan as a whole: Comparison of LTES values and our estimates (in million yen)

	1890	1909	1925	1935	1940
	Gross output				
LTES (Umemura et al., 1966)	590	1,314	4,544	3,176	6,438
This study (regional prices)	532	1,268	4,597	3,058	5,676
This study (national average prices)	531	1,268	4,584	3,052	5,660
	Gross value added				
LTES (Umemura et al., 1966)	469	1,055	3,711	2,542	5,228
This study (regional prices)	462	1,096	3,972	2,560	4,786
This study (national average prices)	462	1,096	3,960	2,554	4,770

Notes:

1. Gross value added from the LTES is gross output figures minus intermediate input figures published in the LTES.
2. The reason for the minor differences in the results using regional and national average prices is that we extrapolated the regional prices of grains (grains other than the six major staple crops) for which we did not have any regional price data, using the national average price trend from the LTES and assuming that regional price differences for these grains were the same as regional price differences for rice and barley, naked barley, and wheat. Consequently, national average prices weighted by prefectural output using our regional price estimates are slightly different from the LTES series.

ucts. These figures imply a rapid increase in per capita output (and therefore, implicitly, food supply, since these items were barely traded with the rest of the world). This picture is the consequence of the backward extrapolation method used by the authors of the LTES estimates. We have to take into consideration that, for most items, LTES output volume series for vegetables, fruits, and edible animal products that cover the period prior to 1905 (or even prior to 1909 in some cases) are estimates. This is another issue we are hoping to address in future research.

e) Estimation of value added

Having estimated prefectural gross output series for individual items, we then aggregated these to calculate total gross output, making various adjustments. Specifically, LTES estimates of input series were adjusted in order to avoid double counting; sericulture inputs (silkworm eggs) as well as green manure and forage crops were therefore excluded; we also regarded part of the feed of agricultural origin as a by-product of agricultural production and therefore excluded this from the input reported in LTES input estimates. Apart from seed, most remaining inputs are non-agricultural products; the total value of these inputs was around 13–14% of LTES output values in

the period 1878–1940 (11.8% in 1890, 13.1% in 1909, 13.7% in 1925, and 13.8% in 1940).

For each given year, we allocated inputs among prefectures assuming that inputs accounted for the same percentage of output in all prefectures. Owing to the lack of information on local prices for these different items, we assumed that regional differences were negligible. Table A2.3 summarizes the results at the national level, providing a comparison of the LTES series and our estimates of gross output and value added. Using local prices or the national average of local prices does not affect the result for Japan as a whole very much. The differences between the LTES series and our estimates of gross output value are due, first, to the fact that we assumed a greater margin (10%) between producer and wholesale prices than Umemura et al. (1966); second, to the fact that our estimates of movements in producer prices over time, which are mainly based on movements in wholesale prices, differ from those estimated by Umemura et al. (1966); and, third, to the fact that we did not include the output value of silkworm eggs both in gross output and in intermediate input, while Umemura et al. (1966) did. Regarding our estimates for 1940, the discrepancy may be also due to the fact that local prices were missing in the *Nihon Teikoku Tokei Nenkan* for that particular year and were therefore extrapolated from price data for 1939 assuming the same variation as in the LTES prices.

f) Estimation of real gross value added series

To construct real GPP series for agriculture, rather than relying on the simple procedure shown in equation (3) using the implicit value added deflator from the LTES by intermediate industry classification, we employed a more rigorous procedure by multiplying the output volume of each item with 1935 prices. Moreover, we estimated not only real series in national average prices, but also in local prices. It should be pointed out that in the case of agriculture, the real series, which are conceptually similar to the real GPP series for other industries, are the real GPP series expressed in national average prices. This is the series we used for agriculture when aggregating all sectors in order to obtain real GPP in national average prices.

Real GPP series expressed in regional prices and national average prices were estimated using the following procedure. We started by estimating gross output and then calculating gross value added by subtracting intermediate input. Real gross output series expressed in 1935 regional prices and national average prices were obtained by multiplying the output volume of a particular product in each year by the 1935 local or national average price for that product. Prices for the six major staple food crops (rice, barley, naked barley, wheat, soybeans, and *azuki* beans) were obtained as described in Section A2.3.1. For prices of the other 13 agricultural products—in addition to tea and cocoons, the six other staple food crops (foxtail millet, barnyard millet, proso millet, buckwheat, sweet potatoes, and white potatoes) and five industrial crops (cotton, hemp, indigo, tobacco, and rapeseed)—we follow the LTES (Umemura et al., 1966) in our assumption regarding regional price differences; that is, we estimated these assuming that the regional price differences for these are the same as the average of the regional price differences for rice and barley (see previous section). For other agricul-

tural products—secondary staple crops (grain sorghum (*morokoshi*), maize, oat, rye, peanuts, peas, broad beans, and kidney beans), vegetables, fruit, and other animal products (meat, poultry, eggs)—we multiplied the output in each year and prefecture by the national price for 1935 published in the LTES (Umemura et al., 1966). In other words, for these products, we assumed that regional price differences are negligible. Meanwhile, the real gross value added series in national average prices were estimated in the same way as the corresponding nominal series.

When calculating gross value added, we did so by subtracting the farm value of inputs from total output. However, in order to avoid subtracting farm inputs twice, we subtracted input goods produced in agriculture (seed, green manure, etc.; see Section A2.3.5 above on the adjustment of input series) from input series. Real input series are then estimated using the same procedure as that used for the nominal input series. That is, input series are estimated assuming that regional price differences for inputs are negligible and that the ratio of inputs to output is the same across prefectures.

Moreover, since the LTES (Umemura et al., 1966) provide unit price series for intermediate inputs of services (those summarily reported under "Other") and these series expressed in 1934–1936 prices are relatively stable, we decided that there would be no problem in using the real intermediate input series of services for all of Japan (in 1934–1936 prices) from the LTES for the estimation of real gross value added series in 1935 prices in this study. However, as a result of this procedure, small discrepancies arise in our estimation between the nominal gross value added for 1935 (valuing inputs in 1935 prices) and 1935 real gross value added (with intermediate inputs of services valued in 1934–1936 prices).

g) Estimation of gross prefectural output of forestry and fisheries

With regard to forestry and fisheries, we employed an extremely simple procedure to obtain GPP. Specifically, we allocated the LTES estimates for Japan as a whole based on the gainfully occupied population in each prefecture in forestry and fisheries. (A description of the estimation of the gainfully occupied population by prefecture and industry is provided in Section A2.6.) That is, we assumed that, in each year, labor productivity (measured in nominal values) was identical across prefectures. In other words, our estimates here ignore the fact that labor productivity may differ as a result of regional differences in the technology level, resources, the capital–labor ratio, etc., and they also ignore regional differences in output and input prices.

A2.3.2 Estimation procedures for the benchmark year 1874

a) Overview

The aim of this section is to explain the estimation procedures for prefectural output and value added in agriculture in 1874. The estimation relies primarily on the *Bussan Hyo*, which, however, suffers from certain limitations. Therefore, before describing the estimation procedures (including the estimation of value added for the entire pri-

mary sector), we discuss these limitations first.

Since the ultimate aim is to assess regional inequalities in value added per capita, the main concern regarding the *Bussan Hyo* data is the extent to which differences in coverage affect total agricultural output figures at the prefecture level. A careful assessment, however, suggests that the *Bussan Hyo* provide fairly dependable information for most items, although some adjustments are required for staples other than rice. The most important items to consider when assessing these differences in coverage can be identified by calculating the share of each item in 1874 in the LTES estimates (Umemura et al., 1966). Staples clearly accounted for the bulk of output value. A simple calculation reveals that rice accounted for 61% of total output value, the subtotal of wheat, barley, and naked barley for 10.6%, potatoes for 2.3%, miscellaneous staple grains for 2.8%, pulses for 4.2%, vegetables for 3.1%, cocoons for 4.4%, and other products of animal husbandry for 0.7%.

For other items, Umemura et al. (1966) do not provide any breakdown. Total output value for these various items is only provided as a subtotal for fruits and seeds on the one hand and for industrial crops on the other. It is possible to calculate output value on the basis of information on output volume and unit prices estimated for a large number of items.

For most other items, total output value in 1874 was negligible. Total output value in agriculture in 1874 was 295 million yen (current yen) according to LTES estimates. This can be compared to the output value for the most important seeds (6.9 million yen for rapeseed and 0.1 million yen for sesame), and industrial crops (6.8 million yen for tea leaves, 1.3 million yen for sugar, 1.1 million yen for *konnyaku*, 1.5 million yen for tobacco, 1.3 million yen for hemp, 6.7 million yen for cotton, 0.8 million yen for Japanese mulberry paper, 1.7 million yen for indigo, and 1.2 million yen for wax from wax trees).

However, some of these minor crops were of paramount importance in some regions, for instance tea in Kyoto, Shizuoka, and Hamamatsu prefectures, or indigo in Myodo prefecture (a prefecture on Shikoku and Awaji islands that, after the redrawing of some boundaries, became part of Tokushima, Hyogo, and Ehime prefectures in 1888). Therefore, information for these items reported in the *Bussan Hyo* should not be neglected.

Bussan Hyo data have been used in a previous study by Furushima (1961) in order to estimate prefecture-level agricultural output values. The study was undertaken before the publication of the LTES estimates and the main objective of the author, it appears, was to measure regional inequality in early modern Japan, including with the help of measures of land productivity. However, the methodology employed for reconstructing series is not described in detail.

The remainder of this subsection will first discuss disparities in data monitoring in the *Bussan Hyo* across Japanese prefecture as well as the internal consistency of the data at the prefecture level. We then explain how we computed output values at the level of the present 47 prefectures and how we adjusted staple output values. Next, we explain the estimation of value added on the basis of information on intermediate consumption reported in the LTES. Finally, we compare the new estimates for agriculture

with LTES figures at the national level and outline how we generated estimates of value added for the entire primary sector.

b) *Assessing the reliability of* Bussan Hyo *data and calculating output volumes and values for the different staples and pulses*

The first step in the estimation of agricultural output is to classify the *Bussan Hyo* data in a coherent fashion. It appears that although officers in charge of the data collection at the prefecture level received clear instructions from the central government, they were constrained by the nature of statistical data available. For this reason, even for the most important single item, rice, the format of reporting is not homogenous. In most prefectures, high, medium, and low quality rice are distinguished. However, in some cases, only the total is available.

The classification in the *Bussan Hyo* is generally the same as in the *Noshomu Tokei Hyo* [Statistical Yearbook of the Ministry of Agriculture and Commerce] published from 1878 onward, which was used extensively for the estimation of the series reported in Umemura et al. (1966). Apart from rice, the staples reported in the *Bussan Hyo* include barley, wheat, naked barley, foxtail millet, barnyard millet, proso millet, grain sorghum, maize, and buckwheat. Sweet potatoes, as well as other roots and tubers, are reported among vegetables, usually with implausibly low volumes, suggesting that this part of the data collection was not regarded as essential, or was almost impossible to implement for practical reasons (lack of information on cultivated acreage for instance). A large number of beans are reported: soybeans, *azuki* beans, cowpeas, broad beans, kidney beans, and peas. Here again, we find that a breakdown into high, medium, and low quality products is often available.

Since information on both output volumes and values is available for most prefectures, it is possible to calculate unit prices and to assess the plausibility of these figures. Overall, these data appear fairly reliable in terms of the internal consistency of the information at the prefecture level as well as across prefectures. In most cases, for a given item, a high quality product is more expensive than a medium quality one, which in turn is more expensive than the low quality one. The comparison across prefectures reveals sizable differences that are nevertheless consistent with information available in other sources for rice, barley, and soybeans. In addition, rice and soybeans are usually the more expensive items, which is also consistent with information reported in other sources. The total volume in tons and the value in current yen for the different staples and pulses for Japan as a whole are presented in Table A2.4.

c) *Information for non-staple items in the* Bussan Hyo *and estimation procedures employed in this study*

In addition to staples and pulses, we also collected information on the most important non-staple items from the *Bussan Hyo* to ensure that our coverage corresponds as closely as possible to that in the LTES. These include a category that can be roughly translated as vegetables that, in addition to vegetables, includes roots and tubers. Large

Table A2.4 Output volumes and values in current yen reported in the *Bussan Hyo* for Japan as a whole

	Tons	Yen
Rice	3,894,586	143,210,101
Barley	760,898	17,225,858
Wheat	227,063	5,119,000
Naked barley	140,967	2,652,886
Foxtail millet	113,979	2,384,061
Barnyard millet	69,289	957,871
Proso millet	19,324	543,263
Grain sorghum	19,056	365,430
Maize	4,464	49,950
Buckwheat	55,517	1,370,919
Soybeans	258,978	7,582,831
Azuki	51,906	1,675,831
Cowpeas, black-eyed peas	5,188	113,840
Broad beans	15,761	367,024
Kidney beans	1,295	22,412
Peas	9,519	191,037
Other beans	2,637	60,802

differences in coverage can be observed across prefectures. We did not attempt to estimate missing data at this stage. Fruits and seeds are combined in another category in the *Bussan Hyo* that is also characterized by important differences in coverage. Here again, we did not attempt to estimate figures that were possibly missing. In most cases, the subtotal for fruits and for seeds was also reported in the *Bussan Hyo*. When this was not the case, we reclassified the different items in order to generate these figures. We also used without any adjustment another category that can be described as medicinal crops.

The *Bussan Hyo* also contain information on tea, which falls under the category "beverage and food items." We estimated the agricultural output value of tea production as the total value of tea leaves and 50% of the value of processed tea. (Due to the lack of information on intermediate consumption in tea processing, we assumed that tea leaves accounted for 50% of output value). Similarly, we estimated the output value of tobacco leaves as 50% of what in the *Bussan Hyo* is listed as processed tobacco, which is reported as a distinct category of items that can be described as tobacco products.

In addition, we examined as carefully as possible a number of other industrial crops that we identified as particularly important on the basis of LTES estimates. Apart from indigo, we identified various types of products as part of the category of items that can be described as tinctorial items and calculated the total for tinctorial items. Similarly, we combined various items corresponding to different forms of wax tree products, mulberry paper, oriental paperbush (*Edgeworthia chrysantha*; the vernacular Japanese name is *mitsumata*), and saffron (used as a natural colorant) in another category of

items labelled "other industrial crops."

We estimated the output value in sericulture using information on cocoons and assuming that the value of cocoons was 50% of the output value of processed silk (yarn or fabric). We included the category "other animal products" listed in the *Bussan Hyo* in the calculation of agricultural output value without adjustment as a proxy for other animal husbandry, although it is likely that, in some prefectures, products from hunting were also included. In order to avoid double counting, we did not take into account other textile products and sugar, since the output value of these items is included in the estimation of value added in manufacturing and we were unable to assess the share of the output value of these items that should be attributed to agriculture.

d) Calculation of agricultural output volumes and values for the 47 present-day prefectures, with adjustments for under-reporting of staple output

Information in the *Bussan Hyo* for 1874 is for the 63 prefectures that existed at that time. We therefore needed to convert the information to the level of the 45 present-day prefectures for which information is available. (Data for Okinawa and Hokkaido are unavailable in the *Bussan Hyo*.) In addition, we checked the consistency of the estimates using output volumes and population estimates. Specifically, we calculated per capita caloric availability. Per capita caloric availability is above 2,200 kilocalories (kcal) per day in most parts of north-eastern Japan, but only around 2,000 kcal in much of central Japan, and much lower in western Japan, in some cases as low as around 1,000 kcal. The average for Japan as a whole is 1,695 kcal. This implies that output figures are too low to be compatible with physiological requirements. Estimates of per capita caloric intake for the late 19th and early 20th century are in a range between 2,200 and 2,500 kcal per capita per day for Japan as a whole (Mosk and Pak, 1978).

Since the caloric availability obtained from the *Bussan Hyo* data is measured on the production side, it does not take into account losses in storage, transportation, and processing (in particular *sake* brewing and noodle processing), as well as volumes of low quality or discarded grains used as feed in animal husbandry activities. Assuming that around 20% of calories from staples were lost due to wastage during storage, transportation, and processing, the gross output volume of staples and beans in terms of gross calorie content that would have needed to have been produced to yield 2,200 kcal available for human consumption is 2,750 kcal per head per day. Output figures cannot be explained by the fact that any shortage in production was made up by imports. International trade figures clearly indicate that imports of staples were almost non-existent. According to LTES series, output volumes of vegetables, fruits, seeds, sugar, meat, eggs, and milk were extremely low in early Meiji.

There is no reason to assume that each prefecture was self-sufficient. It is well documented that a number of prefectures had a structural surplus of grains, particularly rice. The Osaka market and, to a lesser extent, the Tokyo market played a critical role in the allocation of rice throughout the country since at least the mid-Tokugawa period. Moreover, the provisioning of Tokyo and Osaka, with a combined population of

around 1.6 million inhabitants out of a Japanese population estimated at around 33.6 million in 1874, relied on the shipment of rice and other foodstuffs from other prefectures. However, since transporting staples other than rice, wheat, soybeans, and *azuki* beans over long distances was uneconomical, shipment of staples across prefectures only played a limited role in prefectural food supply (with the possible exception of Tokyo and Osaka, which relied on shipments from neighbouring prefectures and the rest of the country). We therefore assume that gross caloric availability on the production side should be at least 2,250 kcal per capita per day (implying a net intake of around 1,750 kcal, assuming that 20% of gross caloric availability is lost in storage, transportation, and processing) at the prefecture level (except in Tokyo and Osaka).

Information reported in the *Bussan Hyo* for non-staple food items implies that vegetables, fruits, nuts, and animal husbandry edible products accounted for an extremely low share of caloric intake. It is therefore possible that the *Bussan Hyo* underestimate output volumes of vegetables, fruits, and nuts. However, the variation in the coverage of items at the prefecture level makes it extremely difficult to reconstruct output volumes. The easiest way to adjust output volumes upward to a level compatible with physiological requirements is to focus on staples.

The difference between physiological requirements (estimated to be around 2,200 kcal per day on the basis of information for the inter-war period, for which food supply data are much more reliable) and the caloric content of output volumes reported in the *Bussan Hyo* can be regarded as concealed or unrecorded output of staples. The total caloric content of edible products other than staples and beans likely was 50 to 100 kcal per day at most. Assuming that losses accounted for around 20% of gross caloric availability, we can therefore estimate the output of staples unrecorded in the *Bussan Hyo* as the additional volume of staples required to reach 2,750 kcal per capita per day at the national level. This additional volume can be calculated by converting into volume of staples the missing calories, with a conversion ratio of 3,500 kcal per kg (which is roughly the caloric content of rice, wheat, barley, millet, and buckwheat).

The upward revision of prefecture-level staple output measured in terms of caloric content is undertaken in two stages. First, prefectural output volumes are adjusted in order to reach at least 1,750 kcal per capita per day in all prefectures except Tokyo and Osaka. For prefectures for which output volumes were above this level the output data were left unchanged. The result of this first adjustment is a rise in caloric content of 177 kcal per capita per day on average at the national level, which is rather limited but helps to eliminate oddities such as per capita caloric availability of only slightly above 1,100 kcal per day in Kochi, Ehime, and Saga. The result yields a new national average of 1,872 kcal per capita per day.

Second, a coefficient of 1.47 is applied to per capita caloric intake for all prefectures, including Tokyo and Osaka. The coefficient is the ratio of the caloric content of 2,750 kcal which we regard as plausible at the national level and the result obtained in the first stage of the adjustment (1,872 kcal). The additional caloric content from staples required to reach this level is 878 kcal per capita per day on average at the national level.

Table A2.5 Estimates of output volumes in this study compared with LTES figures (millions of current yen and percentage of total)

	This study (million yen)	LTES (million yen)	This study (%)	LTES (%)
Rice	143.2	174.7	63.7	61.0
Mugi[a]	25.0	30.3	11.1	10.6
Potatoes		6.6	0.0	2.3
Miscellaneous cereals	5.7	8.1	2.5	2.8
Pulse	10.0	12	4.5	4.2
Vegetables	11.6	9.0	5.2	3.1
Fruits	1.5	1.0	0.7	0.3
Seeds[b]	7.1	7.1	3.1	2.5
Sugar		1.3		0.5
Tea	3.5	6.8	1.6	2.4
Tobacco	1.4	1.5	0.6	0.5
Medicinal crops	0.4	0.2	0.2	0.1
Indigo	2.8	1.7	1.2	0.6
Wax trees, mulberry paper[c]	0.7	1.9	0.3	0.7
Textile crops		8.4		2.9
Other industrial crops[d]		0.9	0.0	0.3
Sericulture	4.6	12.6	2.0	4.4
Other animal husbandry	7.1	2.1	3.2	0.7
Straw goods		0.2		0.1
Green manure		2		0.7
Total	225	286	100.0	100.0

Notes:
a. *Mugi* consists of wheat, barley, and naked barley.
b. Rapeseed, sesame, and other oleaginous crops.
c. Including oriental paperbush and safflower (*carthamus tinctorius*).
d. Other than seeds, tobacco, medicinal plants, textile crops, indigo, wax tree.

Unrecorded output values are estimated by relying on the average unit prices per kg of staples. Total adjusted output value figures are generated for all prefectures first in local prices and then in national prices. Estimates of the concealed or unrecorded output value of staples are calculated on the basis of the price of calories for the different species and the total quantity of calories required to reach 2,750 kcal per capita per head. The price of missing calories is proxied as the unweighted average of the price for (i) rice, (ii) the unweighted average for wheat and barley, and (iii) the unweighted average for other staples (various millets, sorghum, and buckwheat). It is therefore assumed that one third of the missing calories originated from rice, another third from wheat and barley, and another third from other staples. Price figures for a number of prefectures were missing in the *Bussan Hyo* and were therefore generated using available data for neighbouring prefectures. Figures of concealed or unrecorded staple output values in national prices were generated for each prefecture by calculating the total

value in local prices and adjusting for price differences. National total output volumes and values for the different products (or groups of products) are presented in Table A2.5.

In line with the estimation procedure described above, we assume that (i) rice, (ii) wheat and barley, and (iii) miscellaneous cereals each accounted for one third of the estimated unrecorded output volume. The result of this calculation for rice output is almost identical to the LTES estimates (Umemura et al., 1966) using prefecture-level data and a number of adjustment procedures aimed at correcting for the underestimation of cultivated acreage. Although the LTES estimates for rice seem highly plausible, the estimates for other crops seem problematic, and the authors themselves recognize that the margin of error is much larger than for rice. In particular, the paucity of information regarding roots and tubers in the *Bussan Hyo*, particularly for sweet potatoes, does not allow generating plausible estimates at the prefecture level.

e) Estimation of value added in agriculture and in the primary sector (agriculture, forestry, and fisheries)

Having estimated prefectural output volumes and values for individual items, the final step consists of estimating prefectural agricultural value added and prefectural primary sector value added.

Value added in agriculture is estimated assuming that, in each prefecture, intermediate consumption accounted for 5.5% of output value. This figure is the average for 1878-1887 in Umemura et al. (1966) when excluding green manure and feed (12% when these items are included). The *Bussan Hyo* do not include any information on green manure or feed and there is therefore no reason to include these items. Moreover, the exclusion of feed can be regarded as compensating for the underestimation of non-grain staples (roots and tubers) in the *Bussan Hyo*. In principle, the volume of seeds could be estimated relying on information reported in table 4-4 of Umemura et al. (1966) for each staple crop. However, this would require data on the acreage under cultivation for each type of crop, which are not reported in the *Bussan Hyo* and are not available from other sources for the year 1874. The results of this calculation are presented in Figure A2.3, which shows value added using both local and national prices.

Finally, we estimate total value added in the primary sector by extrapolating from estimates for agriculture and the share of fisheries and forestry in the value added in the primary sector estimates at the prefecture level for 1890 (on the basis of LTES estimates at the national level and prefecture-level labour force estimates, assuming that average labour productivity in forestry and fisheries was the same in all prefectures). The results are presented in Figure A2.4 in terms of value added per capita in current yen (at local prices). It should be noted that figures for Hokkaido and Okinawa, which are missing in the *Bussan Hyo*, were generated in the same way as for other prefectures (except Tokyo and Osaka) assuming that food supply consumed in those territories did not originate from other regions.

Figure A2.3 Estimates of per capita value added in agriculture in 1874 (in current yen)

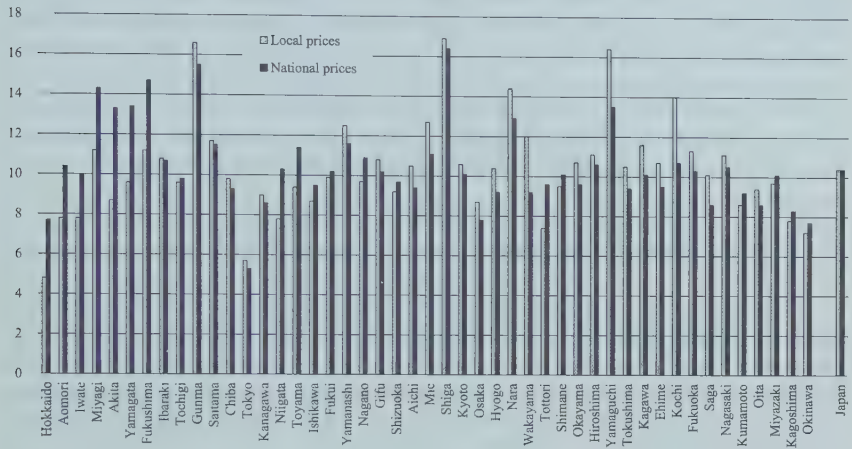
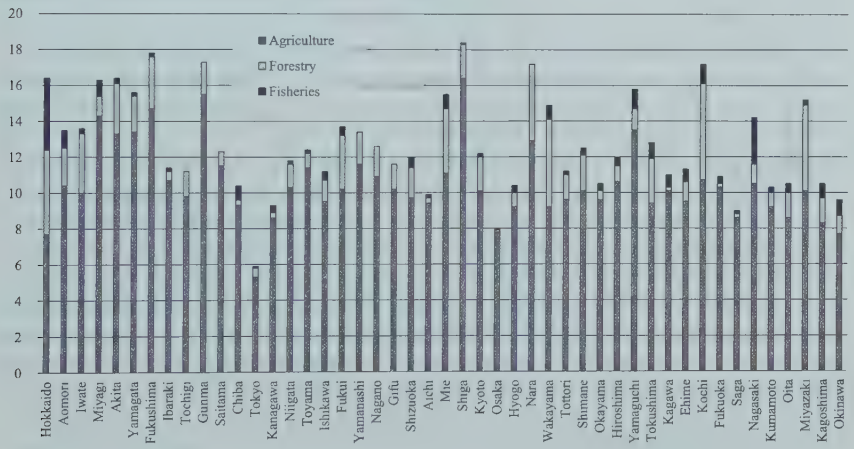


Figure A2.4 Estimates of per capita value added in the primary sector in 1874 (in current yen)



A2.4 Mining and manufacturing

This section explains our procedure for estimating GPP and industrial structure in the mining and manufacturing sectors. Specifically, this section is divided into the fol-

lowing subsections, focusing primarily on manufacturing. Section A2.4.1 provides a description of our data sources. This is followed by a discussion of issues related to the coverage of these data sources (Section A2.4.2) and adjustments we make to compensate for the fact that sources before 1939 do not include small-scale establishments with fewer than five employees (Section A2.4.3). Sections A2.4.4 and A2.4.5 then describe our estimation procedure, respectively focusing on the estimation of value added and the conversion of prefectural output series in local prices to series in national average prices. Finally, Section A2.4.6 provides a description of our estimation of prefectural output in mining.

A2.4.1 Basic data sources

The key data sources for manufacturing are the *Fuken Bussan Hyo* [Tables of Prefectural Products] published by the Ministry of Popular Affairs in the early years of the Meiji period; the *Kojo Chosa* [Factory Survey] covering factories with five or more employees, conducted annually from 1883, and published as part of the *Noshomu Tokei Sho* [Agricultural and Commercial Statistics] by the Ministry of Agriculture and Commerce; and finally the "Kojo Tokei Chosa [Factory Statistics Survey]," begun in 1909 and reported in the *Kojo Tokei Hyo* [Factory Statistics]. In addition, prefectural data are available in the *Fuken Tokei Sho* [Prefectural Statistics] published since the early Meiji period. The following is an overview of the characteristics of each of these sources.

(a) Fuken Bussan Hyo [Tables of Prefectural Products]: 1874

The *Fuken Bussan Hyo*, brought into existence through a Department of State edict dated October 18th, 1870, can be considered to signal the birth of official modern industrial statistic in Japan. The *Fuken Bussan Hyo* are based on a survey of the output of 29 product categories, such as agricultural products, marine products, lumber and wood products, and manufacturing and mining products for each prefecture and their aggregates. However, from 1876 onward, the survey covers only agricultural products and was published by the Agricultural Extension Department of the Ministry of Internal Affairs as the *Zenkoku Nosan Hyo* [Table of National Agricultural Products]. In this study, we rely on the data from the *1874 Fuken Bussan Hyo* to estimate values for our first benchmark year (1874). Specifically, we used the compilation of these data on manufacturing and mining products provided in Hitotsubashi Daigaku Keizai Kenkyujo Kokumin Shotoku Suikei Kenkyukai Shiryo (1959-1964).

(b) Noshomu Tokei [Agricultural and Commercial Statistics]: 1883-1924

With the establishment of the Ministry of Agriculture and Commerce in April 1881, the compilation of output surveys was transferred from the Ministry of Internal Affairs to the Ministry of Agriculture and Commerce. Moreover, in 1883, the "Noshomu Tsushin Kisoku [Regulations for Reports of the Ministry of Agriculture and Commerce]" were enacted and statistics on the manufacturing sector were added to the *Noshomu Tokei*.

In addition, while the *Fuken Bussan Hyo* and the *Zenkoku Nosan Hyo* had only concentrated on output, the *Noshomu Tokei* for agriculture also surveyed land under cultivation and reported separately arable land area for own-farming and tenant farming, while for manufacturing they provide data on the number of factories, production equipment, number of factory workers, and wages. However, these new statistics on manufacturing activities concentrate mainly on textiles and spinning, and no longer report output for all industrial products, which is why we did not use the *Noshomu Tokei* in our estimations for the manufacturing sector. The *Noshomu Tokei* were discontinued after 1924, although the statistics on industrial products in the *Noshomu Tokei* were continued in the *Shokosho Tokei Hyo* [Statistics of the Ministry of Commerce and Industry] based on the "Shokosho Tokei Hokoku Kisoku [Regulations for Statistical Reports of the Ministry of Commerce and Industry]" in 1925.

(c) *Kojo Tokei Hyo* [*Factory Statistics*]: *1909–1938*

The factory surveys conducted on the basis of the above-mentioned "Regulations for Reports of the Ministry of Agriculture and Commerce" of 1883 were revised several times, but in 1909, a new ministerial ordinance ("Kojo Tokei Hokoku Kisosku [Regulations on Reports for Factory Statistics]") was enacted to provide for the collation of a new set of statistics separate from the surveys conducted for the *Noshomu Tokei*, namely the *Kojo Tokei Hyo* [Factory Statistics], which were to focus on factories with five or more factory workers. Moreover, the methodology of data collection, which until then had consisted of the filling in of information by interviewers, was changed to the present self-reporting principle, where the factory owner is obliged to report the information. To begin with, the *Kojo Tokei Hyo* were collected based on a survey conducted every five years, but from 1919 onward they were collected annually.

(d) *Kojo Chosa* [*Factory Surveys*], *Kogyo Chosa* [*Survey of Manufactures*], *and Kogyo Tokei* [*Census of Manufactures*]: *1939–present*

From 1939, the statistics, under the name *Kojo Chosa* [Factory Surveys], started to cover all factories and cottages irrespective of the number of employees. In 1947, the *Kojo Chosa* became the *Kogyo Chosa* [Survey of Manufactures] as the "Designated Statistics Number 10" under the Statistics Law, covering all manufacturing industries as defined in the Japan Standard Industry Classification. The *Kogyo Chosa* became the *Kogyo Census* in 1950 and then the *Kogyo Tokei Chosa* [Census of Manufactures], which continues until today. From 1939 until the present, the results of these surveys have been published as the *Kogyo Tokei Hyo* [Census of Manufactures], and from 1947 onward it is relatively easy to compile and aggregate statistics from the *Kogyo Tokei Hyo*. Therefore, our discussion below concentrates on the period from the early Meiji era until 1940.

(e) *Fuken Tokei Sho* [*Prefectural Statistics*]

The *Fuken Tokei Sho* were published annually by each prefecture from around

1873 onward and provide various statistics for each prefecture as a whole. They started as simple one-page printed statistical tables called "X-ken Ichiran Hyo" ["Statistical Overview of Prefecture X"] or "Y-kenchi Ichiran Hyo" ["Statistical Overview, Y Prefectural Government"] and summarily came to be labeled *Fuken Tokei Sho* based on the "statistics form" introduced by the Ministry of Internal Affairs in 1883. They were renamed again and became the present-day *X-ken Tokei Nenkan* [Statistical Yearbook of Prefecture X]. In addition, various other regional statistics were compiled in the Meiji period, such as the *Shifuhanken Gai Hyo* [Summary Tables of the (Hokkai-do Development) Commission, Metropolitan Prefectures, Feudal Domains, and Prefectures] by the Statistics Bureau as well as the *Chishi Satsuyo* [Topographical Summary], the *Gunson Ido Ichiran* [List of Differences Among Districts and Villages], and the *Chiho Yoran* [Summary of Districts] by the Ministry of Internal Affairs. The *Fuken Tokei Sho* cover the period between the *Fuken Bussan Hyo* of 1874 and the *Kojo Tokei Hyo* of 1909 and are very important statistics, but have the following weaknesses:

1. Inputting the information from each volume of the *Fuken Tokei Sho* is extremely laborious.
2. Until 1883, the coverage of the statistical surveys for each prefecture as well as definitions vary, and it is difficult to make them consistent.
3. Extensive reorganization of prefectures took place between 1883 and 1890, making it necessary to make substantial adjustments for territorial changes.

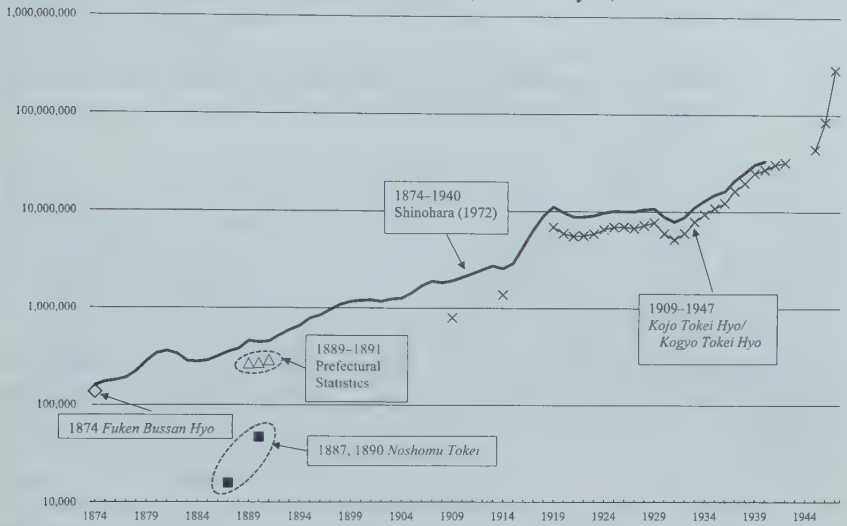
For these reasons, we decided to rely on the aggregate results by prefecture for 1890 prepared by Umemura, Takamatsu, and Itoh (1983). We leave the examination of statistical sources related to the *Fuken Tokei Sho* and their use in the economic analysis of regional developments for future research.[11]

A2.4.2 The coverage ratio of each of the statistical sources, and control totals

One of the shortcomings of the factory surveys mentioned above is that their coverage is incomplete. That is, the surveys concentrate on modern factories and ignore small-scale manufacturing production such as traditional handicraft industry. To take account of this issue, Shinohara (1972) estimated manufacturing industry gross output for all of Japan by painstakingly aggregating and comparing data from a range of different statistical sources, including the ones mentioned above, and, moreover, comparing demand- and supply-side statistics (based on the commodity flow approach).[12] Figure

[11] Another related task is the examination of data in the *Kangyo Nenpo* [Industry Promotion Yearbook], which Matsuda (1978) argues provides more fundamental survey results than the *Fuken Tokei Sho*. Again, this is a task we hope to tackle in the future.

Figure A2.5 Manufacturing industry output in each of the statistical sources and estimates by Shinohara (1972) (in million yen)



Note: The vertical axis shows logarithmic values. The values from the *Kojo Tokei Hyo* are for factories with five or more factory workers. (From 1939 onward, survey results for factories with fewer than five factory workers are available, but not shown in the figure).

A2.5 provides a comparison of the manufacturing output in each of the statistical sources and the estimates by Shinohara (1972).

To estimate prefectural gross value added, we used Shinohara's (1972) estimates as the control total for manufacturing industry gross output for Japan as a whole. Then, using prefectural data from the various sources (*Fuken Bussan Hyo* for 1874, *Fuken Tokei Sho* for 1890, and *Kojo Tokei Hyo* for 1909), we allocated the control total to pre-

[12] Shinohara (1972) applied the following three-step procedure to estimate total output: (1) For output by sector for the years 1919–1940, he used the values recorded in the *Kojo Tokei Hyo* as the basis and added to these the estimated output of factories with fewer than five factory workers, as well as processing fees and repair charges, and output of government-run factories. (2) Using the *Noshomu Tokei Hyo*, he constructed output series for major items going back to the early Meiji period and, using the trend in these time series, extrapolated the series obtained in step (1) back to the early Meiji period. And (3), he adjusted the long-term series obtained in the previous step with data from the 1874 *Fuken Bussan Hyo*.

fectures and, using information on gross value added ratios, estimated the gross value added for each prefecture.

A2.4.3 Adjustments to take account of small-scale establishments and estimation of gross output by prefecture and industry (in local prices)

Concluding that the 1874 *Fuken Bussan Hyo* can be considered to be an exhaustive census, Shinohara (1972) assumed the aggregate output values found therein to be the total output in Japan. We followed this assumption and estimated the gross output for each of the 47 prefectures after making necessary adjustments for the redrawing of prefectural boundaries in the intervening years, applying the procedure described in Section A2.2 based on population data at the *gun* (county) level in 1874.

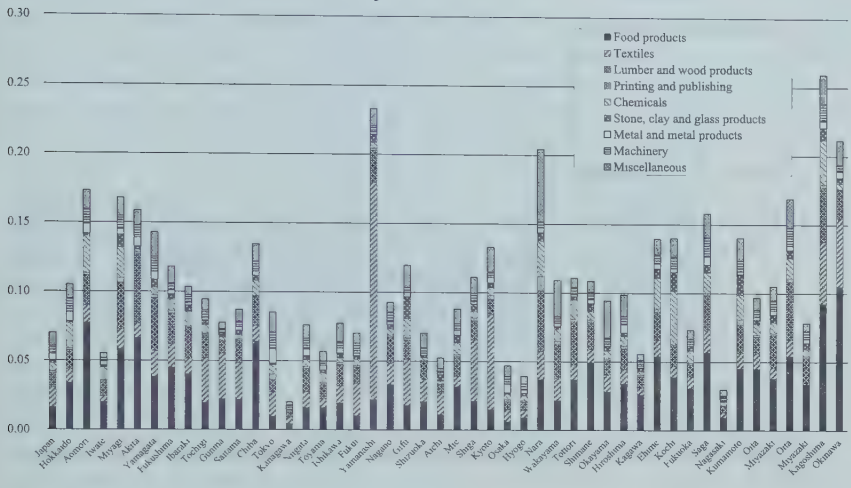
With respect to the data for 1890 in the *Fuken Tokei Sho* and for 1909, 1925, and 1935 in the *Kojo Tokei Hyo*, we regarded the discrepancies between the national aggregate of prefectural outputs in each of the industries and the national output estimates for each industry by Shinohara (1972) to be accounted for by the output of small-scale establishments with fewer than five factory workers. Then, using the 1939 *Census of Manufactures*, which for the first time includes small-scale establishments with fewer than five factory workers, we calculated the output shares of small-scale establishments in total prefectural output by industry and, using these ratios, proportionally allocated the above-mentioned discrepancies. Finally, for 1940, we used the data from the *Census of Manufactures* for that year without this adjustment, since small-scale enterprises are included.

In order to check the validity of this approach, we examined the distribution of small-scale enterprises by prefecture and by industry in 1939, 1941, and 1942 and found this to be stable. In addition, for a longer-term perspective, we calculated the difference between the total number of workers in the manufacturing sector of each prefecture, which we estimate in Section A2.6, and the number of workers in factories with five or more factory workers for the years 1909 and 1925. We then calculated the correlation coefficients between these differences and the regional distribution of workers in factories with fewer than five factory workers in the 1939 *Census of Manufactures*. The correlation coefficients for 1909 and 1925 are 0.93 and 0.96, respectively. This suggests that in the period we focus on there were no major changes in the regional distribution of employment in small-scale establishments. The output share of establishments with fewer than five workers in total output by prefecture and industry calculated from the 1939 *Census of Manufactures* and Shinohara (1972) is shown in Figure A2.6.[13]

A2.4.4 Estimation of value added

Next, we explain our estimation of value added. Unfortunately, ratios of value added by prefecture and industry can be calculated from official statistics only from 1948 onward, while ratios of value added for small-scale establishments with fewer than five

Figure A2.6 Share in total output accounted for by small-scale establishments by prefecture and industry: 1939



employees can be calculated only from 1960 onward. On the other hand, ratios of value added by industry for Japan as a whole can be obtained from 1929 onward. As shown in Figure A2.7, value added ratios declined substantially during the disorder following

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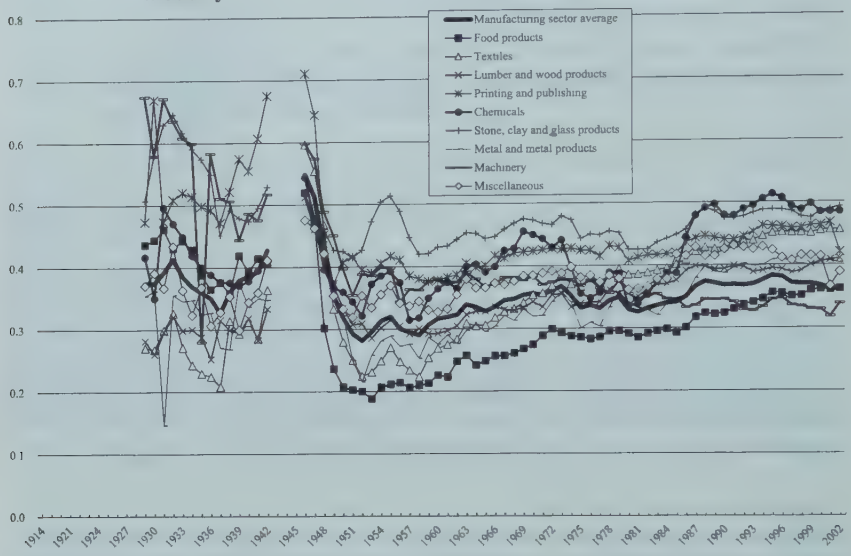
[13] It should be noted that prefectural accounts tend to understate manufacturing activity in metropolitan areas such as Tokyo and Osaka, even today. Consider the case of large firms whose head offices, without any production facilities, are usually located in such metropolitan areas. Such head offices systematically control and manage the firm as a whole and, strictly speaking, such activities should also be regarded as part of manufacturing production. If the head office is located in, say, prefecture A, while the production facility is located in prefecture B, then head office services are "exported" from prefecture A to prefecture B. However, even in today's *Prefectural Accounts*, this kind of head office services production is not adequately considered. For example, looking at prefectural input-output tables, which provide the source data for the *Prefectural Accounts*, such head office activities are treated asymmetrically: while the Tokyo Metropolitan Area has been reporting head office activity separately since the *Showa 60-nen Tokyo-to Sangyo Renkan Hyo* [*1985 Tokyo Metropolitan Area Input-Output Tables*] published by the Statistics Department of the General Affairs Bureau of the Tokyo Metropolitan Government, including exports and imports of head office services to other prefectures, input-output tables of other prefectures do not report exports and imports of head office services. Due to obvious data constraints, this study does not take such head office services into account.

Figure A2.7 Value added ratio by industry for Japan as a whole in manufacturing industry



Sources: For 1929–1938, *Kojo Tokei Hyo*; for 1939–2002, *Kogyo Tokei Hyo* [Census of Manufactures].

World War II, but became relatively stable from the 1960s onward. Moreover, looking at value added ratios for individual industries in the 1930s and 1950s, the differences for many of them do not appear that great. Other notable developments regarding the post-war period that can be gleaned from the figure include the following: (1) Value added ratios differ considerably across industries, but a trend of convergence can be observed over the long term. (2) The value added ratio in the machinery industry declined rapidly in the post-war period. And (3), although the value added ratio of the textiles industry was among the lowest during the pre-war period, it has been rising during the post-war period and is now among the highest.

In addition to the lack of data for the calculation of prefectural value added ratios for the pre-war period, information on gross value added in manufacturing is entirely lacking for the period before 1929. We therefore estimated gross value added ratios by prefecture for the pre-war period using the gross value added ratio for Japan's manufacturing industry overall for 1929 (the earliest year for which data are available) and 1935, and the gross value added ratio by prefecture for establishments with more than five employees reported in the 1950 *Kogyo Tokei Hyo* [Census of Manufactures].[11]

Specifically, we calculated the value added ratio $V_{i,j}(t)$ in industry i in prefecture j in year t using the following equation:

$$V_{i,j}(t) = V(t) \times V_{i,j}(50) / V(50)$$

where $V(t)$ is the average gross value added ratio in manufacturing industry in Japan overall in a year close to t reported in either the *Kojo Tokei Hyo* or the *Kogyo Tokei Hyo* [Census of Manufactures]. $V(50)$ is the average gross value added ratio for manufacturing industry overall for Japan as a whole in 1950 and $V_{i,j}(50)$ shows the value added ratio in industry j in prefecture i in 1950. For $V(t)$ for 1874, 1909, and 1925 we used the value for 1929, and for 1940 we used the value for 1935.

A2.4.5 Conversion of prefectural output series into national average prices

The next step we took was to convert prefectural output series to national average prices. We did so by calculating the prefectural unit prices for all items for which both output values and quantities are available in the *Kojo Tokei Hyo* for 1914, 1925, and 1935, and then computing the ratio of the prefectural price to the national average price for each item. Observations for which the ratio exceeded 2 or fell below 0.5—reflecting, for example, differences in quality—were treated as outliers and discarded. Having done so, we then obtained the weighted relative average prices for each industry and prefecture using prefectural output as weights.

The further back we go, the smaller is the number of items for which we can match output values and quantities. For prefectures and industries for which we could not obtain a sufficient number of items, we substituted missing values with data from the closest year for which data are available. This means that for relative prices for the benchmark years of 1890 and 1909, we used the corresponding relative prices for 1914, and for 1940 those for 1935.

Using the comparison of relative prices of gross output by prefecture and industry, we converted the gross value added in local prices into gross value added in national

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[14] The LTES estimated time series of the value added ratio of Japan's manufacturing sector overall for the period before 1929 using the following equation (Ohkawa, Takamatsu, and Yamamoto, 1974):

$$\frac{Y(t)}{T(t)} = \frac{P(t)X(t) - Q(t)M(t)}{P(t)X(t)} = 1 - \frac{Q(t)}{P(t)} \times \frac{M(t)}{X(t)}$$

where T stands for gross output, Y is net value added, P is the manufactured goods price index, Q is the intermediate goods price index, X is the index of output volume, and M is the intermediate goods input volume index. However, assuming that the intermediate input ratio in production remains fixed over time, they used the value for 1930 and substituted the ratio of the intermediate goods price index and the manufactured goods price index, Q/P, into the above equation, and calculated the net value added ratio for each year.

average prices. It should be noted that in doing so, we did not change the value added ratios to take account of prefectural differences of intermediate goods prices.

The national total gross value added for each of the 10 manufacturing subsectors in national average prices thus obtained should, as mentioned in Section A2.2, in principle be identical to the national total of gross value added in local prices of each subsector. In subsectors where the two are not identical, we multiplied the prefectural gross value added of this subsector in national average prices by the ratio of the national total gross value added of this subsector expressed in local prices over national total gross value added of this subsector expressed in national average prices.

A2.4.6 Estimation of mining output

Output by prefecture for the mining industry is taken from the *Honpo Kogyo no Susei* [Trends in Japan's Mining Industry] for each year (published from 1906 onward) compiled by the Bureau of Mining, Ministry of Agriculture and Commerce, and the *Honpo Kogyo no Susei 50 Nenshi* [A 50 Year History of Trends in Japan's Mining Industry] published by the Research and Statistics Department, Minister's Secretariat, Ministry of International Trade and Industry (1963–1964). However, because for 1890, output by type of product is reported only in terms of volume, we calculated the national average price for each product, using the output value and volume data for each product estimated by Shinohara (1972). We then multiplied this with the output volume of each product in each prefecture and calculated the nominal output for each prefecture in national average prices for 1890.[15]

Next, to convert prefectural output series into local prices, we proceeded in the same manner as for manufacturing industry. That is, we calculated the prefectural unit prices for all items for which both output values and volumes are available and then obtained the weighted average of the ratio of prefectural prices to national average prices using output as weights. However, for 1890 (due to the lack of data), in order to convert output series in national average prices into output in local prices, we used the values for 1909 (and similarly, for 1890 and 1909, for items for which data also were not available, the values for 1925 or 1935). Moreover, we again readjusted the output values for each prefecture so that the national total of prefectural mining output obtained in this manner equals the estimates of total nominal output calculated by Shinohara (1972).

For the calculation of value added, we calculated the gross value added ratios for metal, coal, oil, and all the other types of mining products, respectively, using data on gross output values and intermediate input values in the 1935 *Honpo Kogyo no Susei*. We then calculated nominal gross value added by prefecture by multiplying these gross

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[15] The output of iron and steel as well as non-ferrous metals of smelting plants attached to mining activities is separated from mining and included in the metal industry in the manufacturing sector.

value added ratios by the nominal output by prefecture for each benchmark year.

A2.5 Construction and tertiary industry

In this section, we explain the estimation of gross value added in construction and tertiary industry. In the LTES (Ohkawa, Takamatsu, and Yamamoto, 1974), tertiary industry is classified into three sectors, namely, commerce-services B; transport, communication, and utilities (gas, electricity, water); and public administration, professionals, and domestic servants, etc.[16] In the industry classification for gross value added in this study (consisting of 16 categories), we merge "commerce-services B" and "public administration, professionals, and domestic servants, etc." and refer to this sector as "commerce and services" and the remaining tertiary industries as "transport, communication, and utilities."

Compared with the agriculture and mining and manufacturing sectors covered so far, obtaining data by prefecture on the tertiary sector is extremely difficult. In fact, the situation is not much better with regard to aggregate data at the national level. As a result, the approach taken in the LTES (Ohkawa, Takamatsu, and Yamamoto, 1974) was to estimate output from the income side rather than the production side as for the other sectors. Although this approach gives rise to some concern, we had no choice but to follow this approach in our estimates for this sector.[17]

To begin with, let us present an outline of our estimation method. Simplifying considerably, the estimation from the income side can be represented by the following equation:

Income=Gainfully occupied population×Per capita income

The income referred to here is a mix of incomes consisting of wage incomes and operating surpluses. Because the income calculated on the basis of this equation is net value added at factor cost, if we adjust this for indirect taxes minus subsidies as well as fixed capital depreciation, we obtain gross value added at market prices. The estimation procedures we actually employed can be broadly divided into two types, depending on whether it was possible to obtain per capita income data by prefecture or not. For industries for which per capita income data by prefecture were available, it is possible to calculate prefectural gross income by multiplying prefectural per capita income with

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[16] The sector labels here follow the LTES (Ohkawa, Takamatsu, and Yamamoto, 1974). For a definition of commerce-services B, see Section A2.5.1 below.

[17] However, we hope that in the future we may be able to conduct estimates from the production side as there is an abundance of data at least on certain industries in the tertiary sector, such as transport and communication, finance, and public administration. Estimating gross value added from the production and the income side and being able to compare the two would be of great significance, but because this requires an enormous amount of work, we were not able to do so in this study.

the number of occupied persons by prefecture and industry. (The estimation of the gainfully occupied population by prefecture and industry will be explained in Section A2.6.) On the other hand, for industries for which such data are not available, we took the LTES estimates of national total income in a particular industry and allocated these to the different prefectures based on prefectures' share in the national total of gainfully occupied persons in that industry; finally, combining this with information on prefectural differences in per capita income in other industries, we calculated prefectural income in the industries in question.

In practice, the only industry for which we were able to obtain information on per capita income by prefecture is commerce-services B (specifically, on corporations and unincorporated proprietors who paid taxes). Thus, for prefectural income differences in other industries, we relied on information for commerce-services B. The exception is the construction industry, for which we used prefectural differences in manufacturing sector labor productivity.

As described in the preceding sections, for agriculture, forestry, and fisheries as well as mining and manufacturing, we took price differences between regions with regard to nominal output into account and calculated two types of series, one in local prices and one in national average prices. However, because we were unable to obtain data on regional price differences for service industries, we only calculated prefectural income in local prices. Moreover, we also use these values for analyzing prefectural differences in the macro economy as a whole. In other words, for the construction and tertiary industries, we examine prefectural differences in gross value added ignoring prefectural price differences with regard to goods and services produced or intermediate input.

A few remarks about the estimates for 1890 are in order. As will be explained in the following section, to estimate the gainfully occupied population by prefecture and industry, we mainly had to rely on our estimates for 1906 to 1940, since earlier data are extremely scarce. For some industries, data on the gainfully occupied population at the national level are available, and we allocate these to each of the prefectures using information for 1906. For industries where no such data are available, we used the share of the gainfully occupied population in the relevant industry in the prefectural population in 1906 and multiplied this by the prefectural population in 1890. Because information for 1890 on per capita income is also difficult to come by, we generally obtained income estimates for 1890 relying on indirect methods such as using data for 1897. Accordingly, the reliability of these estimates is also rather weak.

Finally, let us explain our estimation approach for 1874, which differs from that for the other years. Like for the other years, the estimation is based on the gainfully occupied population in the tertiary sector overall; unlike for the other years, however, we do not multiply the gainfully occupied population in the sector by per capita income but instead by real labor productivity in 1874, which we estimated as follows. Taking our estimates of real labor productivity in the tertiary sector overall from 1890 onward, we calculated the annual rate of change for the period 1890–1909, which is 1.2%, and for the period 1909–1925, which is 1.4%. Given this acceleration in the rate of labor productivity

growth, we assumed that labor productivity growth accelerated at an even pace over the period 1874–1925 (that is, we assumed that each year the labor productivity growth rate increased by the same fraction of a percentage point) and used the labor productivity growth rates for the period 1874–1890 (which cumulatively yield an increase in labor productivity of 13.4% over the period) to obtain estimates of real labor productivity in the tertiary sector in 1874.

Next, we converted real values into nominal values using the following approach. Because production costs tend to decline in industries with rapid labor productivity growth, the price deflators for such industries tend to increase at a lower rate than in other industries. And since labor productivity growth in the tertiary sector generally is slower than in mining and manufacturing (excluding construction), the price deflator for the tertiary sector tends to rise at a faster rate than that for mining and manufacturing. This was indeed the case during the period 1890–1909, when the deflator for the tertiary sector rose at an annual average rate of 4.6%, while the value added deflator for mining and manufacturing rose at an annual average rate of 3.7% (for a difference of 0.9 percentage points), and the period 1909–1925, when the two rates were 5.8% and 4.7%, respectively (for a difference of 1.1 percentage points). Therefore, assuming that the pattern was similar during the period 1874–1890, we took the average of the difference during the two following periods (i.e., 1 percentage point) and added this to the average annual rate of increase in the mining and manufacturing deflator for 1874–1909 (1.5%), yielding an average annual rate of increase for the tertiary sector deflator of 2.6% (Table A2.6), with the discrepancy of 0.1 percentage points due to rounding. Finally, using the tertiary sector deflator obtained in this manner, we converted real gross value added in 1874 into nominal gross value added.

A2.5.1 Commerce-services B

Commerce-services B in the definition of the LTES (Ohkawa, Takamatsu, and Yamamoto, 1974: 130) consist of a mixture of service categories such as merchandising business, intermediary brokerage business, finance and insurance, leasing, hospitality, eating and drinking places, entertainment, etc. The estimation in this study follows the estimation procedure of Ohkawa, Takamatsu, and Yamamoto (1974), but uses the revised estimates of the national total of gross income obtained by Settsu (2009) as control totals. The estimation procedure can be summarized as follows. As already mentioned, because total income in this sector is calculated as the gainfully occupied population multiplied by per capita income, except for 1890 we took the data on the gainfully occupied population in the commerce sector from Section A2.6, which deals with the estimation of the gainfully occupied population by industry, and, following the LTES (Ohkawa, Takamatsu, and Yamamoto, 1974), divided this into the following five categories: (1) corporations, (2) single proprietorships (business tax payers), (3) single proprietorships (business tax exempt), (4) family employees, and (5) employees; moreover, we separately estimated the number of those from other industries engaged in by-employments in the commerce sector.

Table A2.6 Annualized rate of change in the price deflator

	All industries	Agriculture	Forestry	Fisheries	Mining	Manufacturing	Construction	Domestic trade and service industries	Transport and communication, and utilities
1874–1890	1.42%	0.93%	1.07%	0.25%	1.52%	1.46%	−1.49%	2.60%	
1890–1909	3.95%	2.87%	4.14%	5.87%	2.87%	3.74%	3.46%	4.53%	2.30%
1909–1925	5.81%	6.81%	5.81%	4.12%	3.74%	4.82%	6.16%	5.97%	4.23%
1925–1935	−2.06%	−3.70%	5.11%	4.04%	0.39%	−3.67%	−3.95%	0.04%	−2.13%
1935–1940	8.67%	13.16%	17.81%	16.23%	11.20%	10.35%	13.91%	3.68%	7.21%
1940–1955	35.87%	35.48%			33.15%	35.80%	30.44%	36.05%	35.32%
1955–1970	5.66%	6.29%			1.18%	3.46%	7.08%	7.53%	2.34%
1970–1990	5.01%	3.92%			3.03%	3.42%	7.99%	5.73%	4.59%
1990–2008	−0.82%	−1.69%			−1.29%	−2.68%	0.57%	0.02%	−1.58%

Note: The growth rates for 1940–1955 are based on Mizoguchi (2003).

In previous work, two different methodologies of subdividing commerce services can be found—that employed by Ohkawa, Takamatsu, and Yamamoto (1974) and Takamatsu (1975), and that employed by Umemura et al. (1988). Here, we followed the latter, except that we also distinguish between tax-paying and tax-exempt proprietorships. However, because we detected some problems in the prefectural figures for the sum of these proprietorships (tax-paying and tax-exempt) for 1888 in the *Noji Chosa Hyo* [Agricultural Survey] published by the Department of Agriculture and Commerce that Umemura et al. (1988) used, we did not conduct estimates for the period before 1906.[18] In addition, rather than using the share of proprietorships in the number of gainfully occupied persons published in the 1920 *Population Census*, as Umemura et al. (1988) did, we calculated this share using the figures obtained after the reclassification of industries (see Section A2.6). Finally, the number of employees (category (5) above) from 1906 to 1913 was calculated as the residual (i.e., the total number of gainfully occupied persons in commerce-services B minus the number of gainfully occupied persons in categories (1) to (4)) and in some cases we obtain slightly negative values. In these cases, we estimate the number of employees using the share of employees in the gainfully occupied population for the nearest year and adjusted the total by subtracting the excess part from the number of family employees. For 1890,

[18] Specifically, we found 12 prefectures for which the number of proprietorships in 1888 seemed to be unreasonably large. This means that if the numbers are indeed excessive, the estimates of the number of gainfully occupied persons in commerce-services B in 1885 in Umemura et al. (1988) on the basis of these records will also be too large.

figures for the number of employees were obtained by dividing the total for Japan for that year taken from Umemura et al. (1988) and allocating this using prefectures' share in the gainfully occupied population in 1906.

An important factor we cannot ignore in national income estimates based on the income approach is income from by-employment. By-employment is of course considered in the estimation in the LTES, but in this study, we employed a different procedure for the estimation of the number of those engaged in by-employment based on Settsu (2009).[19] Because the details of the procedure are described in that study, we will not repeat them here, but put simply, the estimation procedure consists of regressing the share of those whose principal occupation is in classifications other than commerce and transport and communication that are engaged in commerce or transport and communication on the share of those occupied in agriculture among all occupied persons as well as the population density, and then inserting the actual values of the explanatory variables into the estimated equation to obtain estimates of the number of those engaged in by-employment for each prefecture.

Next, for the per capita income for tax-paying single proprietorships for 1925 and 1935, we used the net income per entrepreneur from the business income tables (individuals) in the *Shuzeikyoku Tokei Nenpo Sho* [Statistical Yearbook of the Tax Bureau] published by the Tax Bureau of the Ministry of Finance, which is the same source as that used by Ohkawa, Takamatsu, and Yamamoto (1974) to calculate income in the benchmark years in the LTES.[20] Because net income by prefecture is available only up to 1936, for 1940 we used the values for 1936. Moreover, since business income tax was imposed only from 1927 onward, similar data for earlier years are unavailable. Accordingly, for 1925 we used figures for 1927 on the net income subject to business income tax, for 1909 we used the sales proceeds of wholesale and retail trade, and for 1890, we used the sales proceeds of wholesale and retail trade for 1897.[21]

For income of corporations, for 1925, 1935, and 1940 we took the per firm profit calculated by deducting the losses of loss-making firms from the profits of profit-making firms in the *Kaisha Tokei Hyo* [Tables of Statistics of Corporations] and for 1890 and 1909 the per firm income of type I income tax reported in the *Shuzeikyoku Tokei Nenpo*

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[19] However, it should be noted that both in the LTES and in this study, by-employment in public administration or as a professional or domestic servant is not considered in the estimation using the income approach.

[20] The business categories we used for the estimation are the same as the ones used in Ohkawa, Takamatsu, and Yamamoto (1974).

[21] An alternative method for 1925 would be to use the sales proceeds of wholesale and retail trade, as for 1909 and 1890. However, looking at the sales proceeds in 1925, the differences between prefectures seem too large and we therefore decided not to employ this methodology here. Another reason for employing the figures for 1927 is that these data cover not only wholesale and retail trade but also other subsectors of commerce-services B.

Sho. There are many problems with using type I income tax for our analysis, since it applied not only to commerce and services but to all corporations, including those in other industries; however, these are the only data available that we could use.

For the other categories, that is, tax-exempt single proprietorships, employees, and those engaged in by-employment, we calculated an index of income differences using the per capita income by prefecture for taxpaying single proprietorships mentioned above and converted the national per capita income for each of the categories re-estimated by Settsu (2009) into prefectural values. Because this procedure applies the income differentials of high income categories to low income ones, this may be problematic.

Using these estimates of the number of gainfully occupied persons and the per capita income by category, we then calculated prefectural income for each benchmark year and adjusted the obtained values so that they are consistent with the national totals reported in Settsu (2009). In addition, we allocated to each of the prefectures interest income received from other industries and imputed rent using the share of prefectures' commerce-services B income in income for Japan as a whole.

A2.5.2 Public administration, professionals, and domestic servants, etc.

In the LTES (Ohkawa, Takamatsu, and Yamamoto, 1974), income for the public administration, professionals, and domestic servants, etc., categories are all estimated separately, but in this study we decided to estimate them together. There are two reasons for this. First, in the estimation of the number of gainfully occupied persons, it is not possible to distinguish between public administration and professionals. And second, the figures on the number of gainfully occupied persons as domestic servants, etc., in Ohkawa, Takamatsu, and Yamamoto (1974) differ considerably from those in Umemura et al. (1988). What is more, as previously mentioned, data on the gainfully occupied population by prefecture are unavailable for 1890. For this reason, we calculated income by prefecture in 1890 by allocating national total income in this sector in 1890 estimated by Settsu (2009) to each of the prefectures using the prefectural composition of the gainfully occupied population in these categories in 1906.

Information on prefectural differences in per capita income in these categories is also unavailable. We therefore employed the index on prefectural income differences obtained from the per capita income of taxpaying single proprietorships in commerce-services B to convert prefectural incomes calculated from the national average income into values that take income differences into account. As for commerce-services B, prefectural incomes are then adjusted so that the national total obtained by multiplying the number of gainfully occupied persons by per capita income is consistent with the values obtained by Settsu (2009).

Moreover, these categories and commerce-services B were aggregated as "trade and services."[22] The reason is that we cannot divide the adjustment item (indirect taxes minus subsidies) and fixed capital depreciation (with all values taken from

Ohkawa, Takamatsu, and Yamamoto, 1974), which are necessary for the calculation of gross value added at market prices, into each of these categories. We then allocated the adjustment item and fixed capital depreciation to the different prefectures using prefectures' share in the national total of "trade and services" net income. This implies that the share of indirect taxes minus subsidies and fixed capital depreciation in net income is assumed to be identical in all prefectures.

A2.5.3 Transport, communication, and utilities; construction

For transport, communication, and utilities, as well as construction, we generally used the same estimation procedure as for public administration, professionals, and domestic servants, etc. However, data on the number of gainfully occupied persons by prefecture for the utilities and construction industries are unavailable. (In the estimation of time series of the gainfully employed population by sector in Section A2.6 below, these industries are included in manufacturing). Therefore, we needed to conduct separate estimates of the gainfully occupied population in these industries for the benchmark years for our income estimation here. For 1925, we used the averages of the 1920 and 1930 *Population Censuses* (after reclassifying industry categories; the same applies below), and for 1935, the average values of the 1930 and 1940 *Population Censuses*. For 1909, we calculated the shares of both sectors in the manufacturing sector using data from the 1920 *Population Census* and then computed the number of gainfully occupied persons in each of the two sectors by multiplying the shares with the 1909 data for manufacturing employment in each prefecture. For 1890, we proceeded as follows. First, because manufacturing employment data by prefecture are unavailable, we calculated the number of gainfully occupied persons by prefecture in the utilities and construction sectors in 1906 using the same method as for 1909. Second, we then calculated the gainfully occupied population in the two sectors in each of the prefectures in 1890 by multiplying the share of the gainfully occupied population in the two sectors in the total prefectural population in 1906 by the prefectural population in 1890. In doing so, we adjusted the prefectural figures for the gainfully occupied population in these two sectors in 1906 so that the national total was consistent with that in the LTES (Umemura et al., 1988).

Finally, per capita income was estimated using the same procedure as that employed for public administration, professionals, and domestic servants, etc., except that for utilities and construction, we calculated the index of regional income differences using the prefectural per capita income in the manufacturing sector and not that in commerce-services B.

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[22] This corresponds to what Ohkawa, Takamatsu, and Yamamoto (1974) label "commerce-services A."

A2.6 Prefectural populations and gainfully occupied population by prefecture and industry

In this section, we explain our procedures for estimating prefectural populations (Section A2.6.1) and the gainfully occupied population by prefecture and industry (Section A2.6.2).

A2.6.1 Prefectural populations

While economic studies rely on a variety of data, among the most basic and essential must be counted population data. This is certainly the case in our attempt here to estimate prefectural income for pre-war Japan, for which data on prefectural populations at the time are indispensable. Yet, in practice, obtaining such data is not a simple matter. Of course, from 1920 onward, when Japan first started to implement its *Population Census*, highly reliable population statistics by prefecture are available and in this study we use the *Population Census* figures as they are, with only minor adjustments, such as changing them to year-end figures. The challenge is obtaining prefectural population statistics for the period before that.

As is well known, until the implementation of the first *Population Census* in 1920, the population was recorded on the basis of family registers. However, since these family registers relied on self-reporting, delays and omissions mean that it was difficult to capture the population accurately. Nevertheless, as shown by Takase (1991) and Saito (2002b), around 1890, when death certificates became a requirement, reports on deaths appear to have been more or less accurate. This means that the greatest remaining problem in estimating prefectural populations is to adequately capture domestic population movements.

Domestic population movements before 1920 were recorded through the "temporary residence" (*kiryu*) system. *Kiryu* means that someone resides somewhere other than the place of principal register (*honseki*) for more than 90 days. The temporary resident was obliged to submit an "incoming temporary residence notification" at the place of temporary residence and an "outgoing temporary residence notification" at the place of principal register, and the temporary resident was then recorded in the temporary residence register through this notification.[23] Moreover, the temporary residence notification system required the submission of a departure notification upon leaving a place of temporary residence, of a return notification to the place of principal register upon returning to the place of principal register, and of a change of temporary residence notification to the place of principal register when moving to a third area. Based

[23] For details on the temporary residence system, see Saito (1973) and Itoh (1983). A brief explanation of temporary residence statistics is provided in the appendix of Saito (1998).

on these notifications, temporary residence registers were kept. Consequently, if we add the population of incoming temporary residents in the temporary residence registers to the principal registered population (*honseki jinko*) and subtract the population of outgoing temporary residents, this makes it possible to obtain the de facto population of each prefecture. In fact, for years before the 1920 *Population Census*, the officially reported "de facto" population for each year was calculated using this method.

In other words, the "de facto" population of each prefecture was calculated as follows:

Current resident population=
Principal registered population+Incoming temporary population−
Outgoing temporary population

If notifications of incoming and outgoing temporary residents accurately reflect actual population movements, and as long as there are no large problems with regard to figures on the principal registered population, then the statistics on the "de facto" population should also be more or less accurate. However, in practice, incoming temporary residents often did not submit an outgoing temporary residence notification at their principal residence or a departure notification at their temporary residence, so that the incoming temporary resident population in the temporary residence registers increases cumulatively and the national total of incoming temporary residents exceeds that of outgoing temporary residents (in theory, the two should be equal). That is, there is a tendency for the reported "de facto" population of each prefecture to exceed the actual population.[24]

Complicating matters further, periodic adjustments were made to the temporary residence records (*kiryu seiri*). These adjustments, which are known to have been implemented in cities in many regions of Japan during the first half of the Taisho period (Taisho period: 1912–1926), took the form of field surveys conducted in order to correct for discrepancies with regard to incoming and outgoing temporary residents. Incoming temporary residence notifications of non-existent incoming temporary residents were removed from the records, as were outgoing temporary residents that did not submit an outgoing temporary residence notification, with the aim of arriving at figures that are

[24] The government authorities at the time also recognized this excess in the incoming temporary residents population, and when publishing statistics for the "de facto" population by prefecture, calculated two time series: an "A type" (*koshu*) population series in which the figures from the registers are used as they are; and a "B type" (*otsushu*) population series in which the surplus in the number of incoming temporary residents was proportionally subtracted using the following ratio: (incoming temporary residents + outgoing temporary residents in a particular prefecture)/(incoming temporary residents + outgoing temporary residents for all of Japan). The term "reported 'de facto' population" in this study in all cases refers to the "A type" population series.

close to the actual population. For our purposes, these adjustments of temporary residence records pose a problem: while the resident population figures should be close to the true population at times when such adjustments were made, these adjustments give rise to large discontinuities in the population time series.

How to overcome these two problems regarding the recorded "de facto" population—that is, that it systematically overstates the actual population in most years, and the discontinuities introduced by the occasional adjustments—presents a major challenge. Against this background, the procedure we employed is as follows. First, for the period from 1920 onward, we used the prefectural population data published by the Statistics Bureau of the Ministry of Internal Affairs and Communications converted to year-end population data. Second, we divided the period prior to 1920 into two subperiods, 1890 to 1897 and 1898 to 1919. For the period from 1898 to 1919, we distinguished between prefectures comprising the six largest cities (i.e., the prefectures of Tokyo, Osaka, Kyoto, Aichi, Kanagawa, and Hyogo) and other prefectures, and then estimated the population as follows.

(a) Prefectures other than those comprising the six major cities

(i) Using the reported de facto prefectural populations from the *Nihon Teikoku Jinko (Seitai) Tokei* [Population Statistics of Imperial Japan],[25] published by the Cabinet Bureau of Statistics every five years from 1898 onward, as benchmarks, we calculated the growth rates between these benchmark years using the fixed percentage method and took the five-year moving average of the growth rate.

(ii) When there are discontinuities in the population series as a result of the adjustment of temporary residence records, we connected the population growth rates before and after the discontinuity using the recorded population for each year from the *Fuken Tokei Sho*.[26]

(iii) We then calculated prefectural populations for 1918, extrapolating backward using the annualized growth rates from 1920 to 1925. Using the population figures for 1918 thus obtained, we employed the population growth rate obtained in the previous step and estimated prefectural populations back to 1898.

(iv) Next, aggregating the prefectural population figures for each year and comparing the result with the national population for each year reported in the LTES (Umemura et al., 1988), we allocated the residual based on prefectures' share in the national population. (However, the prefectures comprising the six largest cities

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[25] In 1898, *Nihon Teikoku Jinko Tokei*, thereafter *Nihon Teikoku Jinko Seitai Tokei*.

[26] Although the *Nihon Teikoku Jinko Seitai Tokei* provide population data only at five-year intervals from 1898 to 1918, while annual data are available from the *Fuken Tokei Sho*, we use the data from the former as benchmarks because the *Nihon Teikoku Jinko Seitai Tokei* were compiled by the national government and research suggests that they are more reliable than the *Fuken Tokei Sho* compiled by prefectural governments. For details, see Itoh (1983: 55–58).

described below were excluded from this procedure.[27] Finally, we smoothed the figures we obtained using five-year moving averages.

(*b*) *Prefectures comprising the six major cities*

For prefectures comprising the six major cities the basic estimation procedure is similar to that for the other prefectures, but it differs in that we replace the population data for these cities from the *Nihon Teikoku Jinko Seitai Tokei* with the estimated city populations from Itoh (1983). Moreover, as mentioned, we excluded these prefectures when allocating the residual in step (iv) above, that is, we subtracted the population of the six prefectures from our estimate of the national population and the national population reported in the LTES (Umemura et al., 1988).

Summing up the procedure for the period from 1898 to 1919, the basic strategy of our estimation is not to rely on the reported "de facto" population figures, since, as explained above, they overstate the actual population, but instead to regard the implied growth rates as more reliable, take the earliest available prefectural population statistics, those from the 1920 *Population Census*, and then extrapolate population figures backward using the implied growth rates.

Next, let us explain how we estimate prefectural populations before 1898. Because the historical sources for population data before and after 1898 differ and, as a result, the treatment of incoming and outgoing temporary residents also differs, the population data cannot be directly linked. Nevertheless, given the lack of a more appropriate methodology at present, we obtained prefectural population estimates for 1890 by extrapolating backward from 1898 using the growth rates of the reported "de facto" population in the *Nihon Teikoku Minseki Koko Hyo* [Table of Households and Population of Imperial Japan] by the Ministry of Internal Affairs.[28] Similar to our estimation for the period after 1898, we calculated the moving geometric averages of the growth rate series and adjusted the prefectural population estimates so that the national total was consistent with the LTES (Umemura et al., 1988). However, because we once more took the moving averages following this adjustment, our estimates differ slightly from those in the LTES.

Finally, for prefectural populations in 1874, we used the prefectural populations on a family register (*koseki*) basis for 1874 published in the *Ishin-igo Teikoku Tokei Shiryo*

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[27] Population estimates in the LTES (Umemura et al., 1988) for 1871 to 1920 are for the population of Japanese in Japan proper and do not include foreigners, while those for 1920 onward cover the entire population. To obtain series for the entire population for the period before 1920, we simply multiplied the series by the ratio of the entire population to the Japanese population in 1920.

[28] In practice, we took the data for the "A type" resident population from the *Meiji 17-nen Yori Do-40-nen ni Itaru Dofuken Genju Jinko* [Prefectural Resident Populations from 1884 to 1907], which is a compilation of the prefectural population data from each of the volumes of the *Nihon Teikoku Minseki Kokohyo*.

Isan, Dai Ni Hen: Genzai Jinko Seitai ni Kansuru Tokei Zairyo [Collection of Imperial Statistical Data after the Meiji Restoration, Part Two: Statistical Sources on the Permanent Resident Population] published by the Cabinet Bureau of Statistics in 1913, adjusted using the population recorded in Umemura et al. (1988) as the control total.

A2.6.2 The gainfully occupied population by prefecture and industry

To estimate the gainfully occupied population by prefecture and industry, we employed the same methodology that Umemura et al. (1988) used for their estimates at the national level in the LTES. However, because it is virtually impossible to estimate at the prefectural level the gainfully occupied population by age group, as Umemura et al. (1988) did at the national level, we cannot estimate the non-employed population based on this information. We therefore decided to estimate the non-employed population at the prefectural level using the mortality tables by industry from the *Nihon Teikoku Shiin Tokei* [Statistics on the Causes of Death in Imperial Japan] published by the Statistics Bureau, Ministry of Internal Affairs. For this reason, the national totals for each industry obtained by aggregating prefectural figures differ somewhat from those in the LTES (Umemura et al., 1988).[29]

Because the procedure for estimating the gainfully occupied population is described in Umemura et al. (1988), we refer the interested reader there for a detailed explanation. Here, we only briefly explain the differences between the estimation in this study and that in Umemura et al. (1988).

The approach employed by Umemura and his colleagues can be summarized as follows. Using the employed population by industry from the 1920, 1930, and 1940 *Population Censuses* as benchmarks, he interpolated or extrapolated for earlier or later years using the number of deaths by industry, data on which are available for 1906 to 1936 in the *Nihon Teikoku Shiin Tokei*. That is, the estimation is based on the extremely strong assumption that there are no differences in mortality rates across industries. Moreover, the estimates of the gainfully occupied population are on the basis of persons' principal occupation and do not include by-employments.

In principle, we estimated the gainfully occupied population by prefecture using the same methodology. However, in some cases, although figures for Japan as a whole can be estimated, it is not possible to obtain prefectural estimates using the same sources and procedures as Umemura et al. (1988). For example, just like Umemura et al. (1988), we reaggregated data at the detailed industry level in order to have consistent industry classifications over time. However, the *Population Census* for 1940, one of the benchmark years, does not provide a breakdown by detailed industry classification of the number of gainfully occupied persons at the prefectural level. (On the other hand, such a breakdown is available in the 1920 and 1930 *Population Censuses*.) We therefore used

[29] Especially in the figures for before 1920, there are larger discrepancies.

the *Showa 15-nen Kokusei Chosa Tokei Genpyo* [Original Statistics Tables for the 1940 Population Census], which provide a detailed industry breakdown, to reaggregate the data.[30]

Moreover, the industry classification in the *Nihon Teikoku Shiin Tokei*, from which we obtained figures on the number of deaths by industry, is not as detailed at the prefectural level as it is at the national level. For that reason, we were forced to confine ourselves in this study to the following broad categories: (1) agriculture and forestry, (2) fisheries, (3) mining, (4) manufacturing and construction, (5) commerce, (6) transport and communication, (7) public administration and professionals, and (8) other (which corresponds to "domestic servants, etc.," in the preceding section). A ninth category is those not gainfully occupied.[31] It should be noted that there are some small inconsistencies between this 8-industry classification and the 16-industry classification used in the estimation of gross value added above. Specifically, while in the 16-industry classification the salt industry is included in the manufacturing sector, it falls under fisheries in the 8-industry classification here. Similarly, in the 16-industry classification the utilities sector (gas, electricity, water) is included in transport and communication, but in the 8-industry classification, it falls under manufacturing and construction. In the calculation of productivity by industry in Chapter 3, we do not adjust for these inconsistencies. It should further be noted that the gainfully occupied population in trade and services in the 16-industry classification corresponds to the total of the gainfully occupied population in commerce, public administration, professionals, and others in the 8-industry classification.

Next, let us explain how we estimated the gainfully occupied population by industry and prefecture for 1874, which posed considerable challenges. The only source data currently available for this purpose are the the *Ishin-igo Teikoku Tokei Shiryo Isan, Dai Ni Hen: Genzai Jinko Seitai ni Kansuru Tokei Zairyo* [Collection of Imperial Statistical Data after the Meiji Restoration, Part Two: Statistical Sources on the Permanent Resident Population], which we also used for the population estimates for 1874. Based on the data in this source, we estimated the gainfully occupied population for the following three sectors: agriculture, forestry, and fisheries; mining and manufacturing plus construction; and services. However, assigning the occupational categories in the original source to these sectors is anything but straightforward, for the following reasons. First, the source contains a number of rather peculiar occupational categories, which, apart from civil servants such as clerks, soldiers, and police officers, also include professional categories such as scholars of English, French, and medicine as well as martial arts mas-

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[30] The Research Centre for Information and Statistics of Social Science attached to the Institute of Economic Research at Hitotsubashi University holds a microfilm copy of this. Details on the *Showa 15-nen Kokusei Chosa Tokei Genpyo* can be found in Documentation Centre for the Japanese Economy, Institute of Economic Research, Hitotsubashi University, ed., (19—) (publication year unknown).

[31] The sum total of these categories equals the total population for each prefecture.

ters. We assumed that these occupations can be included in the service sector. A second and more serious issue is that, in addition to common occupational categories such as "agriculture," "industry," "commerce," "and fisheries," the source also contains the categories "employees" and "miscellaneous," making it difficult to determine what sector these should be included in.[32] We therefore proceeded as follows. Assuming that those falling into these categories worked outside agriculture, we allocated them to the "industry" and "commerce" categories based on the employment shares of these sectors. And third, because in a number of prefectures, such as Gunma, the occupied population share is very low (with the occupied population shares being particularly low in non-agricultural sectors), we used the average values of neighboring prefectures to adjust the gainfully occupied population in non-agricultural sectors.

Finally, as mentioned in the description of the estimation of gross value added in commerce-services B, when estimating the gainfully occupied population by sector, it is important to consider by-employment, which was widespread in Japan during the pre-war period. In this study, we therefore estimated the gainfully occupied population by prefecture and industry taking by-employment into account based on the methodology employed by Saito and Settsu (2010). Since a detailed description of the estimation approach can be found in that study, here we will only provide an outline of the approach.

Specifically, in the present study we consider by-employment focusing on the following three broad sectors: agriculture, forestry, and fisheries; mining and manufacturing (plus construction); and services. We assume that the share of gainfully occupied persons in a particular sector (where they have their main occupation) engaged in by-employment in another sector changed over the course of economic development, so that at the initial stage, by-employment increased as the economy started to develop but that, once a certain level of economic development had been reached, specialization in a particular sector increased, so that by-employment decreased. In other words, if we were to plot the share of those engaged in by-employment on the vertical axis and the level of economic development on the horizontal axis, the graph would show an inverted U curve.

The basic strategy we employ to estimate the share of those engaged in by-employment can be summarized as follows. To represent the degree of economic development, we used the share of those employed in agriculture, forestry, and fisheries in the total gainfully occupied population. We then regressed the share of those engaged in by-employment in the gainfully occupied population on the degree of economic development and used the coefficient we obtained to estimate for each industry the share of by-employed persons for each year and prefecture.

In order to be able to conduct this kind of estimation, we need data in matrix form

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[32] A similar problem is found in historical sources for Britain, where many men were simply described as "labourers" that could be employed in the primary, secondary, or tertiary sector. For details, see Shaw-Taylor and Wrigley (2014).

to know what sector a person whose main occupation was in a particular sector was engaged in in by-employment (for instance, whether a person whose main occupation was in agriculture was engaged in by-employment in agriculture, manufacturing, or services). Fortunately, such data are available for Yamanashi prefecture for 1879 and for Shizuoka prefecture for 1925 on a county basis. We pooled these data and conducted our regression analysis.[33] Having obtained the share of those engaged in by-employment in each prefecture using the coefficient obtained in the regression, we made the strong assumption that those engaged in by-employment divide their working time equally between their main occupation and their by-employment, and adjusted the gainfully occupied population in each sector. This adjustment resulted in a net reallocation of the gainfully occupied population from agriculture, forestry, and fisheries to other sectors, yielding an increase in the occupied population in mining and manufacturing as well as the service sector.[34] We also divided the gainfully occupied population in these three sectors into more detailed categories, but in this case did not take by employment into account. It should be noted that the sector-level labor productivity estimates for the pre-war period in this study all are based on the gainfully occupied population including by-employment.

A2.7 Estimation of indices of prefectural price differences and calculation of prefectural per capita income adjusted for regional price differences in 1950

This section presents the sources and estimation procedures we used for generating proxies of indices of prefectural price differences and estimates of per capita income in 1950 adjusted for prefectural price differences. Since per capita GPP estimates for the post-war period are available only from 1955 onward, we used prefectural per capita income as a proxy of per capita GPP. (It is these estimates of prefectural per capita income that are used in Figure 2.1 in Chapter 2.) These estimates of per capita income in 1950 are also used for comparing per capita GPP in 1925, 1935, and 1940 (Figure 2.4).

The calculation of indices of prefectural price differences is based on the price of a basket consisting of six goods and five services in 1950, using prefectural unit prices and the same basket composition for all prefectures. The prices are taken from *Kouri Bukka Tokei Chosa* [Survey of Retail Prices] published by the Statistics Bureau of the Prime Minister's Office. As for prefectural differences in price indices computed by Japanese authorities for all prefectures from 1955, these are based on unit prices recorded by Japanese authorities in the capital of each prefecture. Regarding the quantities

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[33] Apart from the share of the gainfully occupied population employed in agriculture, forestry, and fisheries, we included a number of other independent variables such as each county's population density.

[34] It should be noted, however, that despite this reallocation, the total gainfully occupied population remained unchanged.

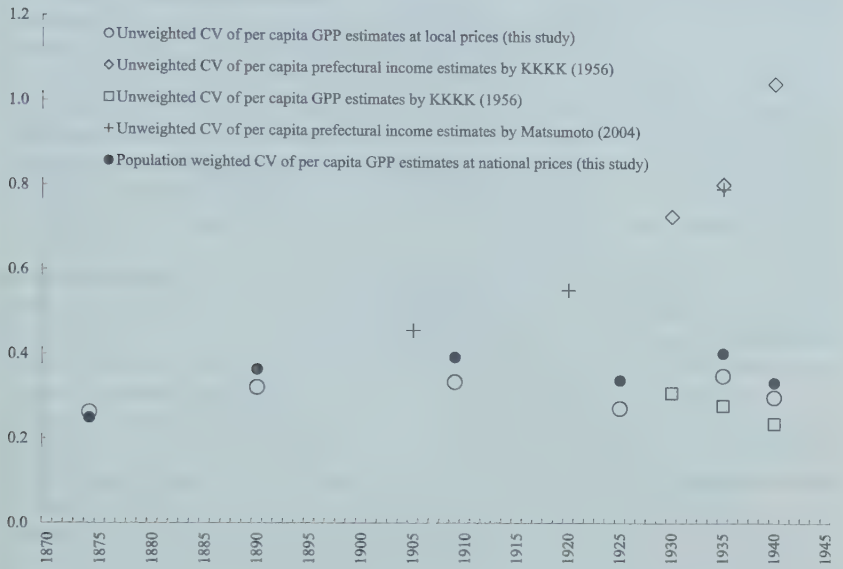
employed in the calculation of the basket price for the goods for which unit price data are available, we relied on surveys of household consumption (*Showa Kokusei Soran*, Vol. 2: 245–248) published by Toyo Keizai Shinposha in 1991. As for services, we arbitrarily set quantities that we regarded as plausible. The following list indicates the basket composition (quantities in parentheses for each of the six goods and five services): rice (110 kg per year), bread (26.6 kg; weight of wheat used as proxy), sardines (14.8 kg; weight of fish used as proxy), pork (0.5 kg), eggs (0.8 kg), sugar (3.2 kg), house rent (15 *tatami*), water (55 liters per day), cleaning (five items per year), bath (180 times per year), and barber (12 times per year).

A2.8 Comparison of our new estimates of GPP for 1874, 1890, 1909, 1925, 1935, and 1940 with earlier estimates of prefectural income or GPP

This section examines how our estimates of prefectural GPP compare to preceding estimates and what they imply in terms of trends in regional inequality. To this end, Figure A2.8 shows the trend in the coefficient of variation (i.e., the standard deviation divided by the mean) of per capita GPP or income based on the estimates obtained in this and preceding studies. Specifically, in addition to our results, the figure shows (1) per capita prefectural income based on the prefectural income estimates for 1930, 1935, and 1940 of the Kokumin Keizai Kenkyu Kyokai (KKKK) [Society for the Study of the National Economy] (1956); (2) estimates of per capita GPP presented also in KKKK (1956); and (3) estimates of per capita prefectural income (in 1934–1936 average prices) for 1905, 1920, and 1935 by Matsumoto (2004). The KKKK estimates were subsequently reported by Keizai Kikakucho Chokan Kanbo Chiiki Mondai Kenkyu Shitsu (1964) and Toyo Keizai Shinposha (1991). However, Toyo Keizai Shinposha (1991) for some unidentified reason only reproduced the estimates of per capita prefectural income, and only these series were used in subsequent studies, in particular Barro and Sala-i-Martin (1992b), Matsumoto (2004), and Ministry of Economy, Trade and Industry (2007). Preceding estimates of GPP or prefectural income expressed in local prices and, when computed, the coefficients of variation were not population weighted. To facilitate comparison, we present in Figure A2.8 the unweighted coefficient of variation calculated using our estimated series in local prices as well as the population weighted coefficients of variation of GPP at national prices. (The reasons why the results for these two series do not differ very much are discussed in Chapter 2). It should be noted that Matsumoto's (2004) figures and our estimates include Okinawa, while those of the KKKK (1956) do not. However, this does not materially affect the results, since, both when using our estimates and the estimates obtained by Matsumoto (2004), the coefficients of variation remain essentially unchanged regardless of whether Okinawa is included or not.

The estimation by the KKKK was conducted as part of the *Showa 30-nendo Tohoku Chiho Sogo Kaihatsu Chosa* [*Fiscal Year 1955 Investigation on the General Development of the Tohoku Region*] for 1930, 1935, and 1940. In addition, KKKK also

Figure A2.8 Coefficient of variation (CV) of per capita GPP or prefectural income, 1874–1940



Sources: See text.

estimated prefectural income for each year from 1948 to 1952 from the production, distribution, and expenditure sides. However, at present, detailed explanations of the estimation methodology can only be found for the estimates for the post-war period, but not for the pre-war period.[35]

If we conjecture from the estimation procedures employed for the post-war period and other national income estimates for the same period, KKKK likely adopted the following approach for the pre-war period. Using prefectural production, distribution (income), and expenditure statistics, the basic idea was to allocate national income esti-

[35] In what detail the methodology and results of the prefectural income estimates in the *Showa 30-nendo Tohoku Chiho Sogo Kaihatsu Chosa* [*Fiscal Year 1955 Investigation on the General Development of the Tohoku Region*] were published is not entirely clear, but some explanations have been published in Kokumin Keizai Kenkyu Kyokai (1955a, b; 1956) (available in the depository of the Research Centre for Information and Statistics of Social Science, Institute of Economic Research, Hitotsubashi University). Two of these volumes, Kokumin Keizai Kenkyu Kyokai (1955a) and (1956), which describe the estimation methodology of post-war prefectural income, have been reprinted in Kokumin Keizai Kenkyu Kyokai (1988).

mated from the three sides to the different prefectures in order to estimate prefectural income from the production, distribution (income), and expenditure sides. The national income figures that are allocated to the different prefectures are probably those from Keizai Shingicho, Kokumin Shotoku-ka [National Accounts Division, Economic Council Agency] (1954) or revised values thereof.[36] However, a major problem of these estimates is that although income from the production, distribution, and expenditure sides should essentially be identical, no attempts have been made to compare the estimates from the three sides and check for discrepancies. Yet, looking at per capita income in Tokyo prefecture, for example, no matter which year we take, income from the production side is only about half of that from the distribution side, so the discrepancies between the two are extremely large.

The estimates of prefectural income from the production side by the KKKK for the pre-war period probably employed the same approach as that taken in this study: that is, estimates for the primary sector and manufacturing industry likely are based on production statistics, while those for construction and tertiary industry are based on income-side information (with estimated per capita value added multiplied by the gainfully occupied population), with GPP in each of these expressed in market prices. On the other hand, the estimates from the distribution side likely are estimates of prefectural income estimated from tax statistics for individuals and corporations, so that, unlike in the case of gross prefectural product, the estimation is based not on where something was produced, but where those receiving the income resided. The estimates from the distribution side are on a factor cost basis, that is, they do not include indirect taxes minus subsidies, and on a net basis, that is, they do not include capital depreciation.[37] Finally, in the case of the expenditure-side estimates, the basis for estimation is not final demand for the output of each prefecture but the final demand in each prefecture (domestic absorption in the terminology of international economics), which does not include net exports of goods and services abroad and to other regions.

However, to compare gross prefectural product and prefectural income, it is necessary to estimate the net income (net receipts of factor income from outside the prefecture) for each prefecture not only by allocating indirect taxes minus subsidies for Japan as a whole and estimating capital depreciation, but also by adjusting for differences between where something is produced and where those receiving the income reside.

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[36] For example, looking at the estimates of income from the production-side by industry (for Japan as a whole) by the KKKK, these are consistent—with the exception of those for secondary industry—with those by the Economic Council Agency.

[37] For the distribution-side estimate, the KKKK calculated two series as control totals: domestic gross income at market prices ("regional gross distribution" in their terminology) and domestic net income at factor prices ("regional distribution income" in their terminology). Of these, the national income series reprinted in Keizai Kikakucho Chokan Kanbo Chiiki Mondai Kenkyu Shitsu (1964) and Toyo Keizai Shinposha (1991) (that is, the series depicted in Figure A2.8) is the latter series.

Similarly, to compare gross prefectural demand and gross prefectural product, it is necessary to estimate net exports of goods and services. However, the KKKK did not attempt to compare the results of the estimates from the three sides, for which the estimation of prefectural income balances and net exports is essential but extremely difficult.

Of the three estimates by the KKKK for the post-war period, which it conducted separately and the mutual consistency of which it did not examine, we believe the estimates from the production side to be the most reliable. Looking at the estimation procedures for the post-war period, the estimates from the expenditure side rely on extremely bold estimations such as of consumption propensities by prefecture. Moreover, because net exports are not included, the underlying definition is very different from that commonly employed for gross prefectural expenditure. As for the estimates from the income side, it appears that the KKKK respectively used corporate income tax (type I income tax) statistics and personal income tax (type III income tax) statistics from the *Shuzeikyoku Tokei Nenpo* [*Annual Report of the Tax Bureau*] (various years) in order to allocate Japan's total corporate income and total personal income across prefectures.[38]

However, estimates from the income side based on tax statistics, and especially income tax statistics including corporate taxes, are littered with various problems. Because corporate taxes are paid at the firm level, tax revenues crucially depend on the location of company headquarters. Probably for this reason, the corporate income of prefectures in which many corporate headquarters are located, such as Tokyo and Osaka, is abnormally high in the estimates of the KKKK. However, essentially, economic activity should be captured not at the firm level but the establishment level.[39] The direct use of personal income tax statistics is also problematic. Personal income tax (type III income tax) payers accounted for less than 10% of the total population at that time (Yazawa, 2004). Consequently, there is a risk that personal income is overestimated for prefectures with a high concentration of taxpayers. The fact that the coefficient of variation in the prefectural income estimates of the KKKK is extremely high is likely caused by the problems associated with the use of this type of tax statistics.

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[38] The cross-sectional correlation between prefectural corporate income estimates by the KKKK and the prefectural corporate income tax revenue reported in the *Shuzeikyoku Tokei Nenpo* is very close to one for 1930, 1935 and 1940. Similarly, the cross-sectional correlation between the prefectural personal income estimates by the KKKK and the prefectural personal income tax revenue reported in the *Shuzeikyoku Tokei Nenpo* is very close to one for the three years.

[39] Japan's present gross prefectural product statistics are based on this approach (see Nagafuji, 2002). Moreover, for this reason, Crafts (2005) in his estimation of regional income in Victorian Britain, for example, adjusts regional data of business and professional profits in accordance with the proportion of receipts accruing to "individuals and firms" as opposed to "companies and local authorities."

Going back now to the results shown in Figure A2.8, the large differences between the coefficients of variation for per capita gross prefectural product based on our estimates and that of the KKKK (1956) as well as the coefficients of variation for per capita gross prefectural income based on Matsumoto (2004) and KKKK (1956) are likely caused not only by the differences in estimation procedures just explained, but also by the differences in underlying definitions. That is, whereas the estimates of gross prefectural product measure production activity at market prices within each prefecture, the estimates of prefectural income at factor cost do not include indirect taxes minus subsidies and, moreover, include income receipts such as investment earnings from other prefectures and abroad (corresponding to a surplus in the balance of income in international balance of payments statistics). This means that prefectural inequality will appear larger in terms of prefectural income than in terms of gross prefectural product if wealthy individuals, who tend to be concentrated in prefectures with a high per capita gross prefectural product such as Tokyo and Osaka receive large amounts of land rent and investment income from other prefectures.

On the other hand, if residents of poor prefectures receive employment income while working away from home, the inequality in prefectural income levels will appear smaller in terms of prefectural income than gross prefectural product. Whether the kind of large factor income transfers between prefectures implied by the discrepancy between the output and income estimates of the KKKK did in practice occur is a matter that still needs to be researched. Looking at the post-war period, for which both prefectural income and gross prefectural product statistics are available, the coefficient of variation for prefectural income in the 2005 *Prefectural Accounts*, for example, is 0.17, which is smaller than that for gross prefectural product, which is 0.20. These issues regarding the differences between prefectural income and gross prefectural product are a topic we would like to leave for future research.

The prefectural estimates from the production side by the KKKK (gross prefectural product) can be considered to be relatively similar to our estimates. If we actually compare them, the coefficients of variation based on the KKKK's estimates are generally smaller than those based on our estimates. Moreover, looking at the ratio of the per capita income of the richest to that of the poorest prefecture for each year, we also find that this is generally smaller: for 1935, the ratio (for Osaka, the richest prefecture, and Kagoshima, the poorest) is 2.7 in the KKKK estimates, compared with a ratio of 4.0 (for Osaka and Okinawa) in our estimates. Similarly, for 1940, the ratios are 2.4 (for Kanagawa and Kagoshima) in the KKKK estimates and 3.3 (for Osaka and Okinawa) in our estimates.[40] Another difference can be seen with regard to the trend in the coefficient of variation over time. Whereas in the case of the KKKK estimates, it consistently declines from 1930 to 1940, based on our estimates it rises from 1925 to 1935 and then falls in 1940. However, overall, if we calculate the correlation coefficient between

[40] Even if we leave out Okinawa from our estimation results, the ratios for Osaka and Kagoshima in 1935 and 1940 are still 3.5 and 3.0, respectively.

their and our gross prefectural output estimates (excluding Okinawa) for 1935 and 1940, the values at 0.96 and 0.94 are quite high, and it can be said that the estimates are relatively close.

That being said, there are two major problems with regard to the national income estimates used as control totals in the estimates of the KKKK. As mentioned earlier, it appears that the KKKK used the national income data from Keizai Shingicho (1954). However, according to Ohkawa, Takamatsu, and Yamamoto (1974), the income estimates by industry in Keizai Shingicho (1954) underestimate values for the manufacturing and construction industries. Moreover, although Ohkawa, Takamatsu, and Yamamoto (1974) do not explicitly say so, looking at one of their tables (Ohkawa, Takamatsu, and Yamamoto, 1974: 156), the agricultural output estimated by the KKKK for 1940 is too large.[41]

Another problem related to this is that if we broadly divide the KKKK estimates into the primary, secondary and tertiary sector, it appears that the increase in primary sector income in rural prefectures greatly contributed to the decrease in interprefectural inequality from 1930 to 1940. However, comparing the share of primary sector income in the per capita income for the total of all industries for Japan as a whole, we find that this is 16.4% for 1935 and 17.5% for 1940, but in the estimates of the KKKK, it is 19.8% and 24.1%, respectively.[42] Although a more detailed examination of the reasons for the decline in inequality is necessary, this comparison suggests that the KKKK estimates exaggerate the expansion in agricultural output during this period and it can be conjectured that this is one cause for the large decline in the coefficient of variation.

Next, comparing our GPP estimates with those obtained by Matsumoto (2004), the differences are substantial. Let us examine how Matsumoto's estimates were generated. According to the preface, the estimate for 1905 is based on the output of all products for all prefectures from the *Fuken Tokei Sho* [Prefectural Statistics], and although the details of the estimation procedure with regard to the construction and the tertiary sector are unclear, it seems that Matsumoto partly used more detailed prefectural statistics than ours. Overall, though, it can be conjectured that the estimation was conducted using a relatively similar approach to ours. For example, the correlation between Matsumoto's per capita prefectural income estimates for 1905 and our per capita gross prefectural product estimates at local prices for 1909 is quite high with a correlation coefficient of 0.94 and, as can be seen in Figure A2.8, the coefficient of variation is also not that different.

On the other hand, for 1935, because he used the prefectural value added ratios from Keizai Kikakucho Chokan Kanbo Chiiki Mondai Kenkyu Shitsu (1964), the corre-

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[41] However, it should be noted that agricultural output values in the annual estimates in Ohkawa, Takamatsu, and Yamamoto (1974) are at market prices, while the KKKK estimates are at factor cost.

[42] Production income by industry was calculated by dividing net domestic income at factor cost.

lation coefficient between Matsumoto's estimates excluding Okinawa and the KKKK estimates of per capita income, at 0.99994, is close to 1.[43] Moreover, the ratios of the prefectural estimates of the two are 1.09 at the most and 1.04 at the least, so that it can be said that the two are very similar estimates. Therefore, Matsumoto's estimates for 1935, and the high coefficient of variation they imply, cannot really be said to be independent estimates of those obtained by the KKKK for per capita income.

[43] A description of the value added ratio by prefecture for 1935 in Matsumoto's estimation is provided in Matsumoto (2004: 92, fn. 7).

Appendix 3

Construction of Data Used in the Analysis for 1955–1969

This appendix explains how we constructed the data necessary for the estimation of industry-level labor productivity in each prefecture and of relative prefecture-level TFP (for all industries together) for the period 1955–1969. The reason that we confine ourselves to the estimation of these series is that for this period insufficient data are available for the estimation of prefectural industry-level working hours and capital stock, which would be necessary for the measurement of prefectural industry-level labor productivity per man-hour and TFP. Therefore, like for the pre-war period, we measure prefectural industry-level labor productivity using gross value added per employed person and estimate the necessary data (GPP, number of gainfully occupied persons by industry and prefecture). What are available for this period, however, are data for the estimation of aggregate prefecture-level working hours and capital stock (i.e., for all industries together). We therefore estimate capital and labor input as well as capital and labor costs by prefecture and use these to measure prefecture-level productivity on a man-hour basis and TFP.

Let us start by describing how we obtain the data needed for estimating prefectural industry-level labor productivity and our estimation approach. Prefectural industry-level data on value added and the number of employed persons needed for the estimation of industry-level labor productivity are readily available, for example from the *Prefectural Accounts* in the case of value added, and from the *Population Census* in the case of the number of employed persons.[1] However, there are various problems with

[1] The industry classification used when estimating labor productivity consists of the same 23 industries (13 manufacturing industries and 10 non-manufacturing industries) as in the R-JIP Database used for the analysis from 1970 onward. For details, see Table A4.1 in Appendix 4.

these data. For instance, in the *Prefectural Accounts*, for value added no breakdown by manufacturing industry is available, and the national totals of the value added by prefecture in the *Prefectural Accounts* are inconsistent with the value added in the *System of National Accounts* (SNA). Moreover, because the number of employed persons in the *Population Census* does not consider by-employment, these figures are not appropriate for measuring labor input. As explained in Appendix 4, for the period from 1970 onward, we used data from the JIP Database as control totals, so that we can deal with these problems, but the JIP Database only starts in 1970, meaning that for 1955–1969 no comparable data are available. Therefore, based on the SNA, we instead estimated control totals both for value added and the number of persons employed, and allocated the value added and number of persons employed by prefecture based on information from the *Prefectural Accounts*, the *Census of Manufactures*, and the *Population Census*.

The relative TFP level for each prefecture is estimated following the approach employed by Tokui, Makino, Fukao, et al. (2013). Concerning the data necessary for the estimation, we obtained prefecture-level value added and persons employed by aggregating the data by industry prepared for the estimation of labor productivity by industry and prefecture described in the preceding paragraph. As for capital stock, we slightly revised the data estimated by Fukao and Yue (2000) and used these revised estimates. Moreover, for the marginal products of capital and labor, which we need for measuring the relative TFP level of each prefecture, we used not information on the income shares of capital and labor (which can be obtained from the *Prefectural Accounts*), but capital costs and labor costs, which we estimated. In particular, with regard to labor costs we followed the approach employed for the JIP Database and estimated labor costs taking those for the self-employed into account.

A3.1 Estimation of value added by industry and prefecture

We estimated value added by industry and prefecture as follows.

(a) We aggregated GDP by economic activity from the SNA and value added by industry from the JIP Database into the R-JIP industries and linked the two sets of series at 1970.[2] This provides us with value added by R-JIP industry for the period 1955–2008 and we used the figures for 1955–1969 as control totals.

(b) We calculated the value added share by prefecture for each manufacturing industry for 1955–1969 using the same approach as in the estimation of value added by prefecture for the period from 1970 onward for the R-JIP described in A4.1.2 in Appendix 4.

[2] From 1970 onward, we adjusted GDP by economic activity from the SNA using the JIP Database, while for the period before 1970, we adjusted it using the link coefficient for 1970 (value added by industry from the JIP Database/GDP by economic activity from the SNA).

(c) For industries in the non-manufacturing sector, we calculated the value added share by prefecture from 1955 to 1969 from the GPP by economic activity in the *Prefectural Accounts*.
(d) We estimated nominal value added series by industry and prefecture by multiplying the shares obtained in (b) and (c) using the value added series obtained in (a) as control totals.
(e) Finally, we constructed value added deflators by aggregating the GDP deflators by economic activity from the SNA and the value added deflators by JIP industry and linking the series at 1970.

A3.2 Estimation of the number of employed persons by industry and prefecture

We estimated the number of employed persons by industry and prefecture as follows.

(a) We aggregated the number of employed persons by economic activity in the SNA and the number of employed persons by industry in the JIP Database into the R-JIP industries and linked the series at 1970. This provides us with the number of employed persons by R-JIP industry for the period 1955–2008 and we used the figures for 1955–1969 as control totals.
(b) We calculated the prefectural share of employed persons for each manufacturing industry for 1955–1969 using the same approach as in the estimation of the number of employed persons by prefecture for the period from 1970 onward for the R-JIP described in A4.3.1 in Appendix 4.
(c) For industries in the non-manufacturing sector, we linearly interpolated the number of employed persons in the *Population Census* and estimated the employment shares by prefecture.[3]
(d) We estimated the number of employed persons by industry and prefecture by multiplying the shares obtained in (b) and (c) using the value added series obtained in (a) as control totals.

A3.3 Estimation of labor quality and working hours by prefecture

Data to estimate time series of prefectural labor quality indexes for the period 1955–1969 unfortunately are unavailable. We therefore estimate prefectural labor quality indexes for 1955 only. The estimation method follows Tokui, Makino, Kodama, and Fukao (2013a, b), but differs in that we estimate labor quality indexes without taking prefectural differences in employment shares across industries into account.

[3] *Population Census* data for the period 1955–1970 are available for the years 1955, 1960, 1965, and 1970.

As for working hours by prefecture, we first estimated national average working hours (for all industries) for 1955–1970 using the *Monthly Labour Survey* (National Survey) and linked the series with that in the JIP Database at 1970. We then estimated prefectural working hours based on working hours in 1955 in this series and prefectural differences in working hours in the 1955 *Monthly Labour Survey* (Prefectural Survey) relative to the national average (Japan = 1).

A3.4 Estimation of prefecture-level capital stock for all industries

We obtained the capital stock by prefecture as follows. We aggregated the private and public capital stock estimated by Fukao and Yue (2000) (referred to as "F-Y capital stock" hereafter) and linked the resulting series at 1970 with the capital stock for all industries from the R-JIP Database.[4]

It should be noted that although the F-Y capital stock and the R-JIP capital stock are both estimated based on the benchmark year method, the estimates for 1970 for the two sets of series are not entirely consistent, since the F-Y capital stock uses data from the 1955 *National Wealth Survey* (expressed in 1980 prices) as the benchmark, while the benchmark for the R-JIP capital stock is the data from the 1970 *National Wealth Survey* (in 2000 prices).[5] However, the correlation coefficient of the estimates for 1970 of the two capital stock of series is 0.975, indicating an extremely strong positive correlation, so that we think that linking the two sets of series in 1970 does not give rise to any major problems.

A3.5 Estimation of the cost of capital by prefecture

To obtain the cost of capital by prefecture, we first estimated the nominal rental price of capital for all prefectures together (investment goods prices × (long-term interest rates − expected rate of change of investment goods prices + capital depreciation rate)) and then multiplied this with the prefecture-level capital stock estimated earlier. Specifically, we estimated the cost of capital by prefecture as follows.

(a) We calculated the nominal rental price of capital for the period 1955–1970 using the interest rate on Telephone and Telegram coupon bonds for long-term interest rates, the private non-residential investment deflator from the SNA for investment goods prices, the rate of change of the GDP deflator from the SNA for the expected

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[4] Specifically, we calculated the link coefficient (R-JIP capital stock/F-Y capital stock) for 1970 and updated the F-Y capital stock series for the period before 1970 using the link coefficient.

[5] Another difference between the two sets of series is, for example, the way that social capital is treated. Whereas the F-Y capital stock includes all categories of social capital stock, the R-JIP capital stock includes only some categories.

rate of change of investment goods prices, and the average rate of capital retirement calculated from the *Gross Capital Stock of Private Enterprises* for the capital depreciation rate.[6]

(b) We calculated the average nominal rental price of capital for all industries and all assets from the JIP Database and linked this with the series obtained in (a) at 1970.

(c) We obtained the cost of capital by prefecture by multiplying the nominal rental price of capital obtained in (b) with the capital stock estimated in A3.4 above.

A3.6 Estimation of labor costs by prefecture

To estimate labor costs by prefecture, we added up labor costs for employees and labor costs for the self-employed (the part of self-employment income that is compensation for labor).[7] While the basic estimation approach follows Fukao and Miyagawa (2008), we simplified parts of the estimation process due to data limitations.

(a) For labor costs for employees, we used compensation for employees from the *Prefectural Accounts*. Labor costs per employed person, which we use below, are obtained by dividing compensation for employees from the *Prefectural Accounts* by the number of employed persons from the *Population Census*.

(b) For labor costs for the self-employed, we followed Fukao and Miyagawa (2008), who obtain labor costs per self-employed person using the following two equations:

$$\alpha = \frac{C^K}{C^K + w^E N^E + w^S N^S} \tag{A3.1}$$

$$\frac{w^S}{\delta} = (1-\alpha)\gamma w^E \tag{A3.2}$$

where α is the cost share of capital in a particular industry, w^S is the labor cost per self-employed person, w^E is the labor cost per employed person, N^E is the number of employed person, N^S is the number of self-employed person, δ is self-employed persons/(number of self-employed persons (owners) + number of family workers), γ is the ratio of the income of self-employed persons (owners) to employed persons, and C^K is the cost of capital. Equation (A3.1) provides the definition of α.

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[6] We first tried using the rate of change in the private non-residential investment deflator for the expected rate of change of investment goods prices, but the changes were quite erratic and there were periods in which the nominal rental price of capital was negative, so that we used the rate of change in the GDP deflator instead. Given that we use the actual rate of change for the expected rate of change, this means that we assume perfect foresight.

[7] It should be noted that the self-employed here comprise both the self-employed (owners) and unpaid family workers.

while equation (A3.2) shows how labor costs per self-employed person (including unpaid family workers) are calculated.

The basic idea underlying the calculation is as follows. Consider a representative self-owned business in a certain industry, owned by a self-employed owner and employing one or several family workers. The business does not employ non-family workers. Fukao and Miyagawa (2008) assume that w^S, δ, and α at this representative firm are identical with the industry averages. Moreover, they divide labor costs evenly among the self-employed owner and unpaid family workers within this firm. The left-hand side of equation (A3.2) denotes the total labor costs (labor costs of the self-employed owner plus those of unpaid family workers) at the representative firm. On the right-hand side of equation (A3.2), γw^E denotes the total income of the self-employed owner and unpaid family workers at this firm. γw^E consists of capital costs and the labor costs of the self-employed owner and unpaid family workers. Therefore, $(1-\alpha)\gamma w^E$ denotes the total labor costs (labor costs of the self-employed owner plus those of unpaid family workers) at the representative firm. This means that equation (A3.2) holds and w^S, the labor costs per self-employed person (including unpaid family workers), must satisfy this equation.

(c) Equations (A3.1) and (A3.2) can be regarded as a two equation system from which we can derive the two unobservable values w^S and α for each industry. We already obtained w^E in (a). δ is calculated from the *Population Census* and γ from the *Employment Status Survey*, with data for intervening years estimated through linear interpolation. By replacing w^S in equation (A3.1) with the right-hand side of equation (A3.2) times δ, we have a quadratic equation of α. Moreover, this equation has a unique solution for α which satisfies the condition $0<\alpha<1$. We used this solution for α and the corresponding w^S for our analysis.

(d) We added up the labor costs for employees obtained in (a) and the labor costs for the self-employed in (c) to obtain labor costs by prefecture.

Appendix 4

Construction of the Regional-Level Japan Industrial Productivity (R-JIP) Database Used in the Analysis for 1970-2008

The analysis in this volume for the period from 1970 onward is based on the Regional-Level Japan Industrial Productivity (R-JIP) Database jointly compiled by the Research Institute of Economy, Trade and Industry and Hitotsubashi University. This appendix provides a detailed explanation of the way the R-JIP Database was constructed.[1]

The R-JIP Database provides annual data from 1970 onward on nominal and real output (on a gross value added basis) and factor inputs (labor and capital) necessary for the measurement of industry-level productivity in each of the 47 prefectures of Japan (data for Okinawa for 1970 and 1971 are not included). The R-JIP Database is a companion to the Japan Industrial Productivity (JIP) Database, which provides detailed industry-level information (currently 108 industries) and input-output tables for Japan as a whole that are made available to the public and have been used for detailed productivity analyses of industries in Japan.[2] The R-JIP Database complements the JIP Database by providing information on industries by prefecture. However, while the R-JIP Database adds information by prefecture, due to data constraints it is simpler than the JIP Database in that there are only 23 industry classifications and it uses output on a gross value added basis without information on input-output relationships.

Nevertheless, the classification into 23 industries, which consist of 13 manufacturing industries and 10 non-manufacturing industries, provides a more detailed industry classification than similar prefecture-level databases constructed so far.[3] The most impor-

[1] The following explanation is based on Tokui, Makino, Fukao, et al. (2013) and Tokui, Makino, Kodama, and Fukao (2013a).

[2] For details on the JIP Database, see Fukao et al. (2007). The JIP Database can be accessed at: http://www.rieti.go.jp/en/database/JIP2012/index.html.

tant source for information on gross prefectural product (GPP) and economic activity by prefecture is the *Prefectural Accounts* published by the Cabinet Office. However, for the period before 1989, the *Prefectural Accounts* do not provide an industry breakdown for the manufacturing sector. Therefore, for the construction of the R-JIP Database, we used annual information from the *Census of Manufactures* to construct data for individual industries within the manufacturing sector.

For the construction of capital input data for the manufacturing sector we used data provided online by the Economic and Social Research Institute (ESRI), Cabinet Office, on *Todofukenbetsu Minkan Shihon Stock* [*Private Capital Stock by Prefecture*] (Japanese only).[4] On the other hand, to construct capital input data for the non-manufacturing sector by industry, we used information from the *Kenchiku Tokei Nenpo* [*Annual Report on Construction Statistics*] (Japanese only) and employed a combination of different approaches to arrive at our estimates, such as relying on the identity that the rate of change in labor productivity consists of the rate of change in total factor productivity (TFP) and the rate of change in the capital-labor ratio.

Further, in constructing the R-JIP Database, we employed values from the JIP Database as control totals. That is, we adjusted prefectural figures for value added, the number of employed persons, and investment flows so that their sum totals are consistent with the values in the JIP Database for the corresponding year and industry. The original prefectural data in some instances show implausible movements and rates of change, and adjusting values to ensure that they are consistent with national totals allows us to correct many of these problems, which is another distinctive feature of the R-JIP Database.[5]

Yet another key feature of this database is that in the process of estimating capital

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[3] For example, the industry classification in Nakajima, Nakahigashi, and Hino's (2002) analysis of gross prefectural product (GPP) by economic activity for the period before 1990 based on the *Prefectural Accounts* distinguishes only 11 industries.

[4] Available at: http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h21stock.html.

[5] Nevertheless, there are some industries in which implausible values or changes remain, such as petroleum and coal products. The national total of value added for the petroleum and coal industry in the *Prefectural Accounts* is only about half of the nominal value added in that industry in the *System of National Accounts* (SNA). Moreover, annual changes in nominal value added also differ between the two. Since the estimates in both sets of statistics are based on the *Census of Manufactures*, we conjecture that the reason for the different results is differences in estimation methods. In the SNA, values in the use table for the base year are constructed from the input-output table and the supply table, and the use table is subsequently updated every year and value added estimated; on the other hand, in the *Prefectural Accounts*, the values are taken directly from the industry data of the *Census of Manufactures*.

stock from investment flow data, we used the average depreciation rate calculated from the JIP Database, so that we construct capital stock data based on the same net capital stock concept as in the JIP Database. Thus, while data on capital stock in Japan are often constructed based on the gross capital stock concept, which focuses only on the physical decay and wear and tear of capital, a major advantage of the R-JIP Database, like the JIP Database, is that it provides estimates of the net capital stock, which also takes into consideration the decrease in the economic value of older capital equipment reflecting technological innovation.

Since it is difficult to estimate housing capital stock by prefecture, prefectural output in the R-JIP Database excludes the imputed rent on self-owned homes. Imputed rent therefore is removed from prefectural value added using information on the composition of output from the *Prefectural Accounts*.

Based on the approach outlined above, the core part of the R-JIP consists of the construction of real value added (output), labor input on a man-hour basis, and capital stock for each of the 23 industries in each of the 47 prefectures for the period from 1970 onward. The JIP Database for the Japanese economy as a whole also contains information on the quality of factor inputs such as labor input by attribute and capital stock by type of capital good, but the regional-level database unfortunately does not include such information. Therefore, when estimating productivity, we supplement information on factor quality in the following way. First, when conducting cross-section comparisons of the relative TFP level of prefectures (or of industries across prefectures),[6] we employ an index of relative labor quality that we construct using data on the number of persons employed by prefecture, industry, and individual attributes (sex, education, age) from the *Population Census*, while for capital we assume that there are no differences in quality across prefectures within the same industry.

On the other hand, when conducting growth accounting, which looks at changes in TFP over time, we employ a time series index of labor quality estimated using data on the number of persons employed by prefecture, industry, and individual attributes from the *Population Census*, just as in the cross-section analysis, while for the quality of capital, we use "quality" information on a national basis from the JIP Database; that is, we employ an index of the quality of capital input by industry, so that our analysis takes changes in the quality of factor inputs into account.[7]

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[6] Our estimation of cross-section relative productivity levels is based on the approach by Caves, Christensen, and Diewert (1982). Although they do not call these productivity levels TFP, the concepts are very similar and following conventions in the literature we use the term TFP here.

[7] For details on the construction of quality indexes in the JIP Database, see Fukao et al. (2007).

A4.1 R-JIP industry classification and estimation of real value added by prefecture and industry

A4.1.1 Industry classification

The correspondence between the R-JIP industry classification and the industry classification in the *Prefectural Accounts*, as well as the correspondence with the industry classification in the JIP 2011, which we use for the control totals, and with the classification of capital by use in the *Kenchiku Tokei Nenpo* employed for the estimation of capital input are shown in Table A4.1.

As can be seen in Table A4.1, the industry classification in the R-JIP from 1990 onward is consistent with the classification in the *Prefectural Accounts* for some of the industries. However, in order to achieve correspondence with the JIP 2011 Database, which we need for our control totals, we had to make certain compromises and group for-profit and not-for-profit activities in the service sector together.[8]

A4.1.2 Estimation of real value added by prefecture

We estimated real value added by prefecture in the following manner.

(a) The *Prefectural Accounts* do not provide a breakdown by industry for the manufacturing sector before 1989. We therefore constructed value added series by prefecture and industry from 1970 to 1997 using data from the *Census of Manufactures*, linked these with the nominal value added for 1997 in the *Prefectural Accounts*, and estimated the industry breakdown of the nominal value added series from 1970 to 2008.[9,10] From this series, we calculated the value added share by prefecture and industry for each industry in the manufacturing sector.

(b) For industries in the non-manufacturing sector, we calculated the value added share by prefecture and industry from 1970 to 2008 from the nominal value added in the *Prefectural Accounts*.

(c) We estimated nominal value added series by prefecture and industry by multiplying

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[8] For instance, some of the industries in the service sector in the JIP 2011, such as JIP industry 80 Education (private, not for profit) are not divided into private (for-profit) and not-for-profit activities, so that we had to group such activities together.

[9] For small establishments we used gross value added. Moreover, when data were not available for reasons of confidentiality, we estimated such data using information on the number of establishments.

[10] Because for some of the years in which we link the data the link coefficient becomes negative, we linked our data using the earliest year (1997) in which the link coefficient was not negative in the most recent *Prefectural Accounts*.

Table A4.1 Industry correspondence between R-JIP, *Prefectural Accounts*, JIP, and *Kenchiku Tokei Nenpo*

R-JIP	*Prefectural Accounts* *Until 1989*	*Prefectural Accounts* *From 1990*	JIP 2011	*Kenchiku Tokei Nenpo*
1 Agriculture, forestry, and fisheries	Agriculture Forestry Fisheries	Agriculture Forestry Fisheries	1–6	Agriculture, forestry, and fisheries
2 Mining	Mining	Mining	7	Mining and manufacturing
3 Food and beverages	Manufacturing	Food and beverages	8–14	
4 Textile mill products		Textile mill products	15	
5 Pulp and paper		Pulp and paper	18, 19	
6 Chemicals		Chemicals	23–29	
7 Petroleum and coal products		Petroleum and coal products	30, 31	
8 Ceramics, stone and clay		Ceramics, stone and clay	32–35	
9 Basic metal		Basic metal	36–39	
10 Processed metals		Fabricated metal products	40, 41	
11 General machinery		General machinery	42–45	
12 Electrical machinery		Electrical machinery	46–53	
13 Transport equipment		Transport equipment	54–56	
14 Precision instruments		Precision instruments	57	
15 Other manufacturing		Other manufacturing	16, 17, 20–22, 58, 59, 92	
16 Construction	Construction	Construction	60, 61	
17 Electricity, gas and water utilities	Electricity, gas and water utilities	Electricity, gas and water utilities	62–66	Facilitating industry
18 Wholesale and retail trade	Wholesale and retail trade	Wholesale and retail trade	67, 68	Commerce
19 Finance and insurance	Finance and insurance	Finance and insurance	69, 70	
20 Real estate	Real estate	Real estate	71	
21 Transport and communications	Transport and communications	Transport and communications	73–79	Facilitating industry
22 Other non-government services	Service activities Producers of private non-profit services to households	Service activities Producers of private non-profit services to households	80–91, 93–97, 100, 104–107	Service activities Administration and education
23 Government service activities	Producers of government services	Producers of government services	98, 99, 101–103	

the shares obtained in (a) and (b) using the nominal value added series from the JIP 2011 Database aggregated by R-JIP industry classification as control totals.

(d) We obtained implicit value added deflators by industry by aggregating industry-level deflators in the JIP 2011 Database into the R-JIP industries. We then uniformly applied these industry-level deflators to all prefectures (i.e., we assumed that industry-level inflation rates are identical across prefectures) to estimate real value added series by prefecture and industry.

A4.2 Estimation of capital stock by prefecture and industry

We estimated capital input by prefecture and industry by constructing the necessary data for capital stock, cost of capital, and capital quality as described below.[11]

A4.2.1 Estimation of capital stock

(A) Manufacturing sector

(a) We used the *Todofukenbetsu Minkan Shihon Stock* [*Private Capital Stock by Prefecture*] data by ESRI to estimate the capital stock for each of the R-JIP manufacturing industries. Because these data are for the end of the fiscal year (end of March), we adjusted them to calendar year data using data for new capital investment and the retirement of capital.

(b) Using the real net capital stock by R-JIP manufacturing industry—obtained by aggregating the values for the JIP 2011 industries (in 2000 prices) into the R-JIP classification—as control totals, we next calculated the deviation rate for each industry from the national total of the prefecture-level capital stock by R-JIP manufacturing industry calculated from (a). We then multiplied the series obtained in (a) by this deviation rate, and after adjusting the series to be consistent with the control total, used this as our final estimate.

(B) Non-manufacturing sector

(a) We aggregated total investment and investment in structures (non-residential) by industry from the JIP 2011 nominal investment matrix into the industry classification in the *Kenchiku Tokei Nenpo* [*Annual Report on Construction Statistics*] and

[11] We reflected the impact of the 1995 Kobe earthquake by adding up the damage rates by industry in the depreciation rate of capital in 1995. We set the damage rates by industry to zero for agriculture, forestry, and fisheries as well as mining, to 0.318 for finance and insurance, to 0.141 for government service activities, and to 0.060 for all other industries.

constructed the ratio of total investment to construction investment for each of the industries in the *Kenchiku Tokei Nenpo* industry classification. The correspondence between the industry classification in the *Kenchiku Tokei Nenpo* on the one hand and the R-JIP and the JIP 2011 on the other is shown in Table A4.1.

(b) From the JIP 2011 Database, we calculated the R-JIP total investment deflator by industry and the rate of depreciation.[12]

(c) We organized the data on investment in structures from the *Kenchiku Tokei Nenpo* by prefecture and by industry, and by multiplying these data with the series obtained in (a) estimated total investment by prefecture and industry.

(d) As Table A4.1 shows, in the case of some non-manufacturing industries, the industry classification in the *Kenchiku Tokei Nenpo* is too aggregated for the R-JIP database. We divide the investment by prefecture and by industry obtained in (c) into the R-JIP industries in the following manner. Denote the rate of change in the capital-labor ratio, z, by $\hat{z}_{i,r} = \Delta Z_{i,r}/Z_{i,r} - \hat{L}_{i,r}$. Since $\Delta Z_{i,r}$ is gross investment minus the rate of depreciation, this can be rewritten as follows:

$$\frac{I^*_{i,r} - \delta_i Z_{i,r}}{Z_{i,r}} = \hat{z}_{i,r} + \hat{L}_{i,r}, \tag{A4.1}$$

where i stands for the industry, r for the region, I^* for our first-step estimation of investment in industry i in region r, Z for the real capital stock, L for the number of employed persons, and δ for the rate of depreciation, which we assume to be different across industries but the same across prefectures. Moreover, lower case variables indicate values per employed person, while variables with a hat indicate the rate of change.

We assume a Cobb-Douglas (value added) production function for each industry in each prefecture. Denoting value added by Y and the share of capital by β, we further assume that β differ across industries but is the same across prefectures. Thus, we use following production functions:

$$Y_{i,r} = A_{i,r} L_{i,r}^{1-\beta_i} Z_{i,r}^{\beta_i},$$

where $A_{i,r}$ denotes TFP in industry i in prefecture r. Differentiating this equation with regard to time and rearranging yields

$$\hat{z}_{i,r} = \left(\frac{1}{\beta_i}\right)\hat{y}_{i,r} - \left(\frac{1}{\beta_i}\right)\hat{A}_i. \tag{A4.2}$$

(Note that we assume that the growth rate of $A_{i,r}$ is the same across all prefectures and is therefore shown as $\hat{A}_i$.)

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[12] Since in the JIP Database the rate of depreciation differs by industry, we obtained the rate of depreciation by industry (average of assets) for the R-JIP Database using the following formula:

$$\delta_i(t) = \{I_i(t) + K_i(t) - K_i(t+1)\}/K_i(t+1)$$

Inserting (A4.2) into (A4.1) and multiplying both sides by Z_i/Y_i yields the following equation:[13]

$$\frac{I^*_{i,r}}{Y_{i,r}} = \frac{1}{\beta_i}\frac{Z_i}{Y_i}(\hat{y}_{i,r} + \beta_i \hat{L}_{i,r} - \hat{A}_i) + \delta_i \frac{Z_i}{Y_i}. \tag{A4.3}$$

The above equation shows the investment-value added ratio by prefecture and non-manufacturing industry. It should be noted that in some cases the first term in parentheses on the right-hand side of (A4.3) is negative: in that case, we replaced the value in the parentheses with zero, assuming that at the very least replacement investment took place.

(e) As the second step, we made our first-step estimation of investment in R-JIP industry i of prefecture r, $I^*_{i,r}$, consistent with our control total of investment in the *Kenchiku Tokei Nenpo* industry j of prefecture r, obtained in (c), in the following manner. Let S_j denote the set of service industries in the R-JIP classification that make up industry j in the *Kenchiku Tokei Nenpo*. We then derived our estimate of investment in R-JIP industry i of prefecture r, $I_{i,r}$, using the following equation:

$$I_{i,r} = \frac{I^*_{i,r}}{\sum_{i \in S_j} I^*_{i,r}} I_{j,r}.$$

We adjusted these second step nominal investment values so that they are consistent with nominal investment in the JIP Database (i.e., the control total) and obtain real values (in 2000 prices) by using the total investment deflator obtained in (b).

(f) We obtained the 1970 benchmark capital stock (in 2000 prices) by allocating the 1970 capital stock by industry in the JIP 2011 Database using the prefectural shares in capital stock in 1970 in the ESRI estimates. Using this as well as the rate of depreciation obtained in (b) and the real investment value (in 2000 prices) by R-JIP non-manufacturing industry and prefecture, we then calculated real capital stock series using the benchmark year method.

(g) When aggregating prefectures' net capital stock in the non-manufacturing sector calculated in (f), there still remained a discrepancy between this aggregated total and the national-level data from the JIP 2011 Database. Therefore, using the real net capital stock by industry from the JIP 2011 Database aggregated into the R-JIP non-manufacturing industries as control totals, we calculated the deviation rate between the aggregated total of the capital stock for each R-JIP non-manufacturing industry calculated in (f) and the corresponding data in the JIP 2011 Database. We multiplied this deviation rate by the series obtained in (f), and after adjusting these series so that they are consistent with the control totals, we used them as our final estimation result.

[13] Note that, as an approximation, we assumed that K/V differs across industries but is the same across prefectures.

A4.2.2 Estimation of the cost of capital

(a) We aggregated the nominal cost of capital (nominal cost of capital services × real capital stock) and the real capital stock from the JIP 2011 Database into the R-JIP industry categories.
(b) From the nominal cost of capital and the real capital stock by R-JIP industry obtained in (a), we calculated the nominal cost of capital services by R-JIP industry (nominal cost of capital/real capital stock).
(c) We assumed that there are no differences in the nominal cost of capital services across prefectures within the same industry and calculated the cost of capital by multiplying the real capital stock by prefecture and R-JIP industry obtained in (b) with the nominal cost of capital services by R-JIP industry.
(d) Finally, we adjusted the nominal cost of capital in step (c) so that the national total of the cost of capital in each industry is consistent with the nominal cost of capital obtained in (a).

A4.2.3 Estimation of the quality of capital

For the quality of capital, we aggregated the index of the quality of capital in the JIP 2011 Database into the R-JIP industry classifications and assumed that there are no differences across prefectures in the quality of capital within a particular industry.

A4.3 Estimation of labor input by prefecture and industry

We estimated labor input by prefecture and industry by constructing the necessary data for the number of employed persons, working hours, labor costs, and labor quality as described below.

A4.3.1 Estimation of the number of employed persons

(a) We aggregated the number of employed persons by industry and prefecture (based on the place of work, not residence) from the *Population Census* into the R-JIP industry categories for five-year intervals from 1970 to 2010.
(b) For industries in the manufacturing sector, we used the number of employed persons in the *Census of Manufactures* by prefecture and R-JIP industry from 1970 to 2010, and adjusted them so that they are consistent with the number of employed persons on the basis of the *Population Census* obtained in (a).
(c) For industries in the non-manufacturing sector, we linearly interpolated the number of employed persons in the *Population Census* obtained in (a) and estimated the employment shares by prefecture and R-JIP industry.
(d) Finally, we aggregated the number of employed persons in the JIP 2011 Database

into the R-JIP industries and multiplied the result by the shares obtained in (b) and (c) to estimate the number of employed persons by prefecture and R-JIP industry.

A4.3.2 Estimation of working hours and labor costs

(a) We aggregated the working hours per worker and the labor costs in the JIP 2011 Database into the R-JIP industry categories.
(b) From the *Monthly Labour Survey* we obtained the deviation rate of hours worked and cash earnings from the national average (national average = 1) by prefecture and industry.[14]
(c) Next, we multiplied the series obtained in (a) with the deviation rate obtained in (b) to calculate the working hours per worker and the labor costs by prefecture and R-JIP industry.
(d) We then multiplied the working hours per worker and labor costs obtained in (c) by the number of employed persons by prefecture and R-JIP industry estimated earlier, to obtain the total hours worked (man-hours) and total labor costs by prefecture and R-JIP industry, and calculated the national total by industry.
(e) Using the total hours worked and total labor costs by R-JIP industry obtained from the JIP 2011 Database, we obtained the deviation rates from the national values calculated in (d) (JIP = 1). We multiplied these with the series estimated in (c) and finally used the results as our working hours per employed person and labor costs.

A4.3.3 Estimation of labor quality

In line with Caves, Christensen, and Diewert's (1982) cross-sectional productivity measurement approach, we measured the quantity and quality of labor input by prefecture as follows.[15] Denoting the cost share of labor input with attribute n in total labor costs in region r by $\omega_{r,n}$ and the labor input (man-hours) with attribute n in region r by $H_{r,n}$, where attribute n consists of N categories comprising industry, sex, educational attainment, and age, we obtain the quantity of labor input in region r relative to the average region, Λ_r, using the following equation:

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[14] The industries for which we carried out adjustments using the deviation rate from the national average calculated from the *Monthly Labor Survey* are manufacturing industry (industries within the manufacturing sector were all treated in the same manner), construction, wholesale and retail, finance and insurance, transportation and communications, and service activities (private, not-for-profit, and government service activities were all treated in the same manner). For all periods we used data on establishments with 30 or more employees.

[15] For a more detailed description of the derivation of the index and the necessary assumptions see Tokui, Makino, Kodama, and Fukao (2013b).

$$\ln \Lambda_r = \sum_{n=1}^{N} \left(\frac{1}{2}\omega_{r,n} + \frac{1}{2}\bar{\omega}_n \right) [\ln H_{r,n} - \ln \bar{H}_n], \tag{A4.4}$$

where $\bar{\omega}_n$ stands for the arithmetic mean of $\omega_{r,n}$ and $\ln \bar{H}_n$ stands for the geometric mean of $H_{r,n}$. Because this index satisfies transitivity, using a particular prefecture s, for example Tokyo, as the standard for comparison, we can obtain the relative quantity of labor input of prefecture r compared to prefecture s (Tokyo in this example) based on equation (A4.4) as follows:

$$\ln \Lambda_{rs} = \ln \Lambda_r - \ln \Lambda_s. \tag{A4.5}$$

Moreover, we can decompose the quantity of labor input Λ into man-hour input H and labor quality (human capital quality) q from $\Lambda = qH$ using the relationship

$$\ln q_{rs} = \ln \Lambda_{rs} - \ln H_{rs}. \tag{A4.6}$$

This allows us to construct an index of the difference in the quality of labor input in prefecture r relative to the reference prefecture s (Tokyo) by inserting into the first term on the right-hand side of equation (A4.6) the quantity of labor input in prefecture r relative to prefecture s (Tokyo) obtained from equations (A4.4) and (A4.5), and by inserting into the second term on the right-hand side the quantity of man-hour input in region r relative to region s (Tokyo).

In the R-JIP Database, using data from the 1970, 1980, 1990, 2000, and 2010 *Population Censuses* on the number of employed persons by sex, age (five-year age groups), educational attainment, and industry of employment (23 industries), and using equations (A4.4) to (A4.6), we calculated the differences in the quality of labor input by prefecture for each year.

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Biographies

KYOJI FUKAO is Professor at the Institute of Economic Research, Hitotsubashi University, as well as a Program Director and Faculty Fellow at the Research Institute of Economy, Trade and Industry (RIETI). Other positions include: Vice-Chairperson of the Working Party on Industry Analysis (WPIA), OECD; Member of the Executive Committee of the Asian Historical Economics Society (AHES); and External Research Associate at the Centre on Competitive Advantage in the Global Economy (CAGE), Warwick University. He has published widely on productivity, international economics, economic history, and related topics in journals such as the *Journal of Political Economy*, *Quarterly Journal of Economics*, *Review of Income and Wealth*, *Explorations in Economic History*, and *Economica*. In addition, he is the author of *Japan's Economy and the Two Lost Decades* (Nikkei Publishing Inc., in Japanese) and, with Tsutomu Miyagawa, the editor of *Productivity and Japan's Economic Growth: Industry-Level and Firm-Level Studies Based on the JIP Database* (University of Tokyo Press, in Japanese).

JEAN-PASCAL BASSINO is Professor of Economics at and Director of the Institute of East Asian Studies at the Ecole Normale Supérieure de Lyon, a graduate school of the University of Lyon (France). His research interests concern long-run changes in living standards, biological well-being, and economic institutions in Japan and other Asian countries, as well as related issues in environmental economics. He has published widely on these topics in international journals such as the *Economic History Review*, *Economics and Human Biology*, *Economic Development and Cultural Change*, and the *Australian Economic History Review*, and has co-edited various books, including *The Economic Relations between Europe and Asia: Organisation, Control, Trade and Investment* (Chandos).

TATSUJI MAKINO is a researcher at the Institute of Economic Research, Hitotsubashi University, specializing in macroeconomics. He is in charge of the estimation of labor force data for the Japan Industrial Productivity (JIP) Database and the compilation and maintenance of the Regional-Level Japan Industrial Productivity (R-JIP) Database, both of which are jointly compiled by Hitotsubashi Univer-

sity and the Research Institute of Economy, Trade and Industry.

RALPH PAPRZYCKI is an independent scholar based in the UK with a long-standing affiliation with the Institute of Economic Research, Hitotsubashi University, most recently as Adjunct Associate Professor. He holds a PhD in Economics from the School of Oriental and African Studies, University of London, and has a wide-ranging research interest in the economy of Japan. His publications include *Interfirm Networks in the Japanese Electronics Industry* (Routledge) and, with Kyoji Fukao, *Foreign Direct Investment in Japan* (Cambridge University Press).

TOKIHIKO SETTSU is Associate Professor in the Faculty of Economics at Musashi University. His research interest focuses on the role of the service sector in economic growth and regional differences in early modern Japan (1868–1940). Based on new estimates of service-sector employment and output, which he compiled as part of his PhD dissertation in 2009, he is currently conducting research (with Osamu Saito) on occupational structure in modern Japan for the International Comparative History of Occupational Structure (INCHOS) project.

MASANORI TAKASHIMA is a researcher and PhD candidate at the Institute of Economic Research, Hitotsubashi University. His main research interest is very long-run Japanese economic development from the ancient to the modern period as well as estimating various economic factors, such as population, production, wages, and prices during and before the Tokugawa period. He also specializes in archives and historical databases.

JOJI TOKUI is a Professor in and Dean of the Faculty of Economics, Shinshu University. He is also a Faculty Fellow at the Research Institute of Economy, Trade and Industry (RIETI), where he is a member of the research project compiling and analyzing the Japan Industrial Productivity Database. Together with Tsutomu Miyagawa, he is author of *The Economics of a Strong Yen* (Toyo Keizai Shinposha, in Japanese). His recent research interests include productivity differences across Japanese prefectures and in particular the role of human capital, the economic effects of the Tohoku earthquake, as well as embodied technological progress and the measurement of capital.

KYOJI FUKAO is Professor at the Institute of Economic Research, Hitotsubashi University, as well as a Program Director and Faculty Fellow at the Research Institute of Economy, Trade and Industry (RIETI). Professor Fukao obtained his M.A. in Economics from the University of Tokyo.

JEAN-PASCAL BASSINO is Professor of Economics and Director of the Institute of East Asian Studies at the Ecole Normale Supérieure de Lyon, a graduate school of the University of Lyon (France).

TATSUJI MAKINO is a researcher at the Institute of Economic Research, Hitotsubashi University, specializing in macroeconomics.

RALPH PAPRZYCKI is an independent scholar based in the UK with a long-standing affiliation with the Institute of Economic Research, Hitotsubashi University, most recently as Adjunct Associate Professor. He holds a PhD in Economics from the School of Oriental and African Studies, University of London.

TOKIHIKO SETTSU is Associate Professor in the Faculty of Economics at Musashi University.

MASANORI TAKASHIMA is a researcher and PhD candidate at the Institute of Economic Research, Hitotsubashi University.

JOJI TOKUI is a Professor in and Dean of the Faculty of Economics, Shinshu University, and a Faculty Fellow at the Research Institute of Economy, Trade and Industry (RIETI).

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